A Consideration of Voting Accessibility for Injured OIF/OEF Service Members: Needs Assessment

July 2012

Contract E4064914
2010 Voting Technology and Accessibility Research – Military Heroes Initiative
CFDA #90.403

PREPARED FOR:
Election Assistance Commission
1201 New York Avenue, N.W.
Suite 300
Washington, D.C. 20005

PREPARED BY:
Human Systems Integration Division
Electronic Systems Laboratory
Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, Georgia 30332

Preface

This technical report documents work performed in the first contract year for a research project entitled "A Consideration of Voting Accessibility for Combat-Injured Service Members", under contract E4064914. The work was performed by the Georgia Tech Research Institute (GTRI) and was sponsored by the Election Assistance Commission (EAC) via a grant to the Information Technology & Innovation Foundation (ITIF). Dr. Brad Fain of GTRI was the Principal Investigator for this effort. Dr. Courtney Crooks and Ms. Carrie Bell of GTRI served as Co-Investigators. Mr. Todd Williams, Ms. Elizabeth Mann, Dr. Shean Phelps, and Mr. Jerry Ray of GTRI made significant technical contributions to this work.

Abstract

The Help America Vote Act (HAVA) disability requirements and the Military and Overseas Voting Empowerment (MOVE) Act have created a need to more closely examine voting accessibility for military voters who are injured and have physical and cognitive limitations.

- Due to the nature of the military environment, particularly in hostile, deployed settings, military personnel experience a range of injuries that differs from those typically found in the general population. Thus, the range of accommodations needed for military voting also differs from those needed for the general population.
    - Injured military personnel are likely to receive treatment or rehabilitation in a district other than the one in which they are registered to vote; therefore, research into military voting must focus on military personnel voting by means of absentee ballots.
- As of July 10, 2012, 49,008 U.S. troops have been wounded during the current conflicts in Iraq and Afghanistan.
    - The Improvised Explosive Device (IED) is the "weapon of choice" for insurgent forces in Iraq and Afghanistan, resulting in a shift in the types of casualties sustained by U.S. armed forces. 81% of all combat injuries related to enemy contact were due to explosions.
    - The most common form of injury in OIF/OEF is "polytrauma" (multiple region traumatic injury), with the average wounded service member having 4.2 different body region injuries. However, traumatic brain injury (TBI) is often referred to as the "signature injury" of OIF/OEF. Other common injuries include post-traumatic stress disorder (PTSD), hearing impairments, and visual impairments.
- While the difficulties imposed by physical disabilities can be fairly straightforward, the effects of TBI and PTSD can affect functioning in cognition, sensation and perception, and emotion, which can cause difficulties in the voting process in more subtle ways.
    - Among other symptoms, individuals with TBI may have difficulty planning ahead and making decisions based on broad input; they may develop depression or panic disorders; and they may develop blurred vision or disconnection between visual perception and visual comprehension.
    - Several aspects of the voting process present accessibility challenges for wounded military personnel, including the accessibility of the physical space in which voting occurs, the design of the ballot (legibility, consistency, and the organization and presentation of information), and the technologies by which ballots are displayed to and marked by voters.
- The research task documented herein was an assessment of the voting needs of injured OIF/OEF personnel. Subsequent tasks in this research effort will involve assessment of existing voting technologies and other technologies that could be incorporated into the voting process to improve accessibility, and the development of technical recommendations to improve voting accessibility to meet the specific needs of wounded military personnel.

Table of Contents

1 Introduction 8
2 Overview of Military Voting 10
3 Overview of the Military Medical System and the Evolution of Warfare 11
3.1 Echelons of Care 12
3.1.1 Level I 12
3.1.2 Level II 13
3.1.3 Level III 13
3.1.4 Level IV 14
3.1.5 Level V 14
3.2 Evolution of Warfare 14
3.2.1 Brief History of Conflict Involving the United States Armed Forces 14
3.2.2 Definition of "Regular Warfare" versus "Irregular Warfare" 14
3.2.3 Changes in Modern Warfare and Effect on the Military 15
3.2.4 The Improvised Explosive Device (IED) 15
4 Needs Assessment for Recently Wounded Warriors 17
4.1 Epidemiology of Current Conflicts 17
4.1.1 Operation Enduring Freedom 17
4.1.2 Operation Iraqi Freedom 18
4.1.3 Operation New Dawn 18
4.2 Literature Review 18
4.3 Distribution of Injuries and Analysis of Associated Barriers to Voting 19
4.3.1 Principal Injuries by Body Region-Overview 19
4.3.2 Common Injuries: OIF/OEF Service Members 20
4.3.3 Voting Accessibility 25
4.3.4 Gaps in Knowledge 26
4.4 Patient Interviews 27
4.4.1 Results 28
4.5 Summary of Lessons Learned 32
5 Key Technologies for Accessible Voting 33
5.1 Common Approaches 33

5.2 Enabling Technologies 33
5.2.1 Screen Magnifier 34
5.2.2 Adjustable Contrast and Brightness 34
5.2.3 Speech Output 34
5.2.4 Speech Recognition 34
5.2.5 Touchscreens 34
5.2.6 Mobile Devices 35
5.2.7 Tracking Technology 35
6 Conclusions 36
References 39
Appendix A: Annotated Literature Review Results 43
Appendix B: Structured Interview Battery 70

List of Figures

Figure 1: Echelons of Military Care Timeline 11

List of Tables

Table 1. Operation Enduring Freedom (OEF) U.S. Casualty Status as of 10 July 2012 18
Table 2. Operation Iraqi Freedom (OIF) U.S. Casualty Status as of 10 July 2012 18
Table 3. Operation New Dawn (OND) U.S. Casualty Status as of 10 July 2012 18
Table 4. OIF & OEF Principal Injuries by Body Region as of 2007 19
Table 5. Counts of Individuals with Amputations by Service by OIF, OEF, and Unaffiliated Conflicts, 2001 to September 2010 25
Table 6: Impairments and Their Impact on Voting by Recently Injured Service Members. 36

Organization of the Report

This report is organized as follows:

- Section 1 defines the purpose and scope of the research documented in this report.
- Section 2 provides an overview of absentee voting procedures for active duty service members, along with a brief description of how absentee voting procedures change after service members transition to civilian status.
- Section 3 describes the structure of the military medical system, and presents information on the evolution of warfare, leading to the extensive use of Improvised Explosive Devices in the current conflicts in Iraq and Afghanistan.
- Section 4 documents the results of the needs assessment for recently wounded service members. Sub-sections present the epidemiology of the current conflicts, a description of the literature review that was conducted (documented in full in Appendix A), information on the distribution of injuries and associated barriers to voting, findings from interviews with injured service members (conducted using the interview battery shown in Appendix B), and a summary of lessons learned during the needs assessment.
- Section 5 describes key technologies for accessible voting.
- Section 6 presents the conclusions from this task, including a table describing common impairments as a result of injuries sustained in the current conflicts, and the impacts of those impairments on voting.

1 Introduction

The Help America Vote Act (HAVA) disability requirements, specifically, Section 301, and the Military and Overseas Voting Empowerment (MOVE) Act have created a need for more closely examining voting accessibility for military voters who are injured with physical and cognitive limitations. This need has become most apparent as a result of reported injury statistics from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF). According to statistics compiled by the U.S. Department of Defense (2012), as of July 10, 2012, 49,008 U.S. troops have been wounded during the current conflicts in Iraq and Afghanistan, many returning from combat with disabilities including loss of limb(s), loss of sight, and/or traumatic brain injury.

The Military Heroes Initiative is an EAC program endeavoring to determine the voting needs of recently injured service members with civilian status, and to support the voting practices of those voters via technology and process implementations. Some areas of concern identified by the EAC include practical and efficient ways to improve existing services and technology offered through centralized resources, and barriers that prevent service members who have been medically discharged from voting privately and independently. EAC is seeking recommendations for better processes as they work with thousands of injured service members in recovery and rehabilitative centers.

The research presented in this report was conducted for the purposes of understanding current limitations experienced by military voters as a result of their injuries and the barriers those voters encounter in the voting process. Further, available and potential accessibility modifications specifically for service-related injuries were researched in order to provide recommendations for implementation within the military voting system. Due to the nature of the military environment, particularly in hostile, deployed settings, service members experience a range of injuries that differs from those typically found in the general population. Thus, the range of accommodations recommended for military voting will likely also differ from those published for the general population.

The plan for research is organized as four interrelated tasks, outlined below, with each task informing the next.

1. Injured service member needs assessment
2. Technology assessment
3. Voting technologies research
4. Development of technical recommendations to improve accessibility

This report addresses Task 1, the injured service member needs assessment. It is primarily aimed at those service members who would be casting an absentee ballot, since injured service members are likely receiving treatment or rehabilitation in a district other than the one in which they are registered to vote. This project required a measure of background research on relevant topics such as common injuries in OIF/OEF service members and voting technologies, followed by data collection directly with individuals of interest to the Military Heroes Initiative (i.e., Wounded Warriors). The needs of service members and the staff that supports them, the maturation of technologies capable of enabling accessible voting, and the usability of voting systems built on those technologies were considered. These considerations will be used to inform the development of prototype voting technology as well as documentation of the findings in a format that is useful to election officials, FVAP, EAC, Voting Assistance Officers, military officials, and the Department of Defense (DoD) Turbo Transition Assistance Program, as well as industry stakeholders interested in deploying accessible voting systems.

The target population served by this research includes recently wounded service members with civilian status who are currently undergoing medical treatment or rehabilitation. Service members for which recommendations were made include, but are not limited to, those that have experienced the spectrum of traumatic brain injuries (TBIs), and combat related injuries resulting in visual, hearing, cognitive, behavioral, and mobility limitations due to trauma or burns. In order to understand the functional limitations the injured service members might experience when engaged in voting activities, a sample of the target population was interviewed using a structured interview battery. The data is summarized in an effort to address problems and issues that injured service members face with respect to mobility, communication, sensory and cognitive limitations, and limitations imposed by assistive technology as well as how technology is used to overcome these issues.

2 Overview of Military Voting

On August 15, 1986, Congress passed the Uniformed and Overseas Citizens Absentee Voting Act (UOCAVA), which provides the legal basis for absentee voting by U.S. citizens who are active members of a uniformed service as well as their spouses and dependents. Active duty service members may request an absentee ballot by completing the Federal Post Card Application (FPCA), or by other means allowed by the states. VAOs are available to assist personnel in requesting an absentee ballot. The absentee ballot is then delivered through the mail, in person, or electronically. Although procedures vary from state to state, ballots received electronically typically must be printed out and completed by hand. Completed ballots may be returned by mail, fax, e-mail, or (in rare instances) electronic submission. This process can be somewhat complicated. For example, in order to return a ballot by mail, the voter may have to place the completed ballot in a privacy envelope, complete a voter affidavit, and place all materials into a return envelope that must be signed and sealed.

Injured service members who cannot complete the ballot on their own may choose to have an assistant help them complete the ballot. The assistant may read the ballot out loud and/or fill the ballot out at the voter's direction. If the voter cannot sign the ballot or can only make an X, the assistant can identify the voter, note that the voter is unable to sign the ballot, and sign his or her own name as the witness.

Once service members have transitioned to civilian status, UOCAVA no longer applies, and they must instead follow the same absentee voting procedures as the general civilian population. General absentee voting procedures vary from state to state, and lack any sort of standardized procedures like those available to active duty service members. VAOs are available to active duty service members but not to those who have been discharged.

3 Overview of the Military Medical System and the Evolution of Warfare

The military medical system "Echelons of Care" (typically referred to as "Levels of Care") refer primarily to combat casualty care (treatment given to the Warfighters from point of injury on the battlefield), movement through the medical evacuation system, and advanced treatment/rehabilitation provided in mobile, and ultimately, fixed facility centers. Post-surgery level of care, discussed later, refers to the level of rehabilitation once the Warfighter is in a more stable environment. These levels of care also correspond to the delivery of care to dependents and DoD civilians, but, this discussion limits itself to care rendered to service members. Figure 1 depicts the process of care through these echelons following a combat injury based on data gathered from Hetz (2006) and provides a typical time course of injury to fit-for-duty evaluation.

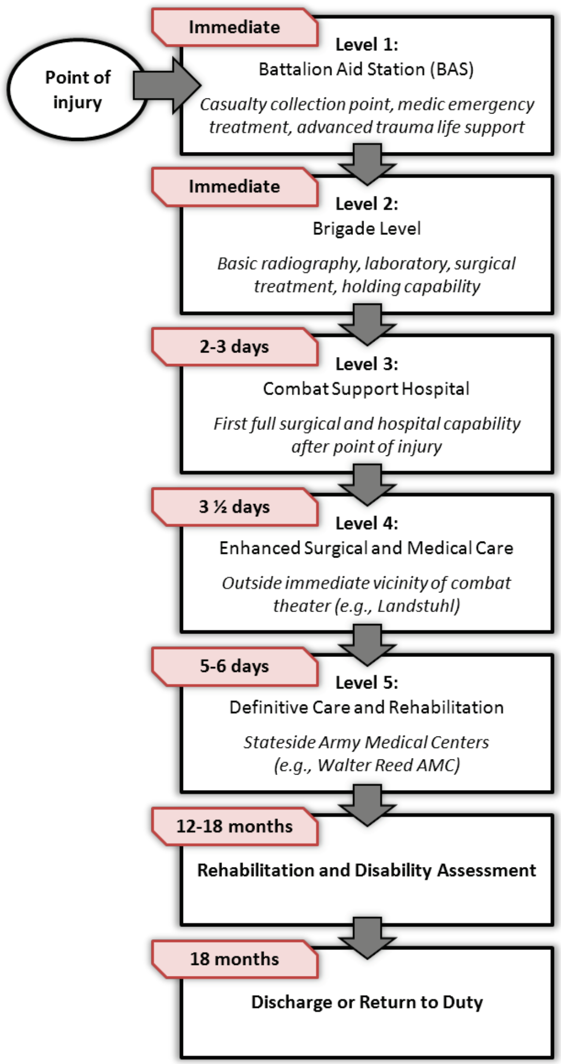

Figure 1: Echelons of Military Care Timeline

A variety of combat-related injuries and functional limitations are associated with each progressive level of care and recovery. For instance, when entering into rehabilitation, patients are presumably at low levels of functioning, whereas patients exiting rehabilitation may have reached satisfactory levels of functioning. Xydakis, Fravell, Nasser, and Casler (2005) offer a useful explanation of the progressive echelons of care in the military system and the method for tracking patients through this system, as well as difficulties in this tracking process. This process is explained further below but it is necessary to understand not only the process itself, but, also important factors such as (but not necessarily limited to) the location and status of individuals within the system, personal limitations in terms of technology, mobility, and entry points within their treatment plan at each level of the process, in order to set the context for recommending appropriate voting accommodations.

3.1 Echelons of Care

The U.S. military medical structure utilizes a system of “Echelons” or “Levels” of care (I-V), each progressively more advanced. Levels I-III are located within the Combat Communications Zone, also known as the “COMMZ”; Level IV care is provided outside the combat zone, yet remains within the Non-Combat “communication zone” of the theater of operations (TO). Care at levels I-IV is delivered “OCONUS” or “Outside of the Continental United States.” Level V denotes medical care conducted within the continental United States (CONUS) and is made up of Department of Defense (DoD) and Department of Veterans Affairs (DVA) medical facilities, which, in the case of activation of the National Disaster Medical System (NDMS), may utilize designated civilian medical facilities to handle overflow of active duty service members requiring care. An understanding of the complete echelon structure is necessary in order to determine where voting assistance can feasibly and effectively be given. At early stages of care, service members may be incapacitated due to severity of injury, or resources to provide voting assistance may not be logistically feasible due to location. Each echelon will be described below; however, it is not until latter stages of care where voting assistance programs might best be implemented.

3.1.1 Level I

Level I (“Echelon I”) entails initial, “point of injury” care provided by combat medics in a theater of hostile and/or non-hostile operations through to that provided at the Battalion Aid Station, also known as the “BAS.” Level I care is formally defined by the delivery of immediate life, limb, and/or eyesight-sparing first aid at the scene of initial injury or wounding. At this level, first aid and immediate life-saving measures may be provided by self-aid, “buddy aid,” or aid from a designated combat lifesaver (nonmedical team/squad member trained in enhanced first aid). Additional aid is provided by the “Combat Medic,” a trained, enlisted trauma specialist (91W) assigned to the medical platoon of an organic maneuver unit and formally trained as an Emergency Medical Technician-Basic (EMT-B).

Other non-licensed care providers with varying levels of training and proficiency include the US Navy’s Special Boat Corpsman, Independent Duty Corpsman (IDC), and SEAL Independent Duty Corpsman (SEAL IDC), the US Air Force Para-Rescueman (PJ), and the US Army’s Special Operations Combat Medic 91W, the Special Operations Medical Technician, and the Special Forces Medical Sergeant 18D.

The primary purpose of this level of care is to provide immediate triage and stabilization of the patient to facilitate transport to the Battalion Aid Station (BAS) or equivalent medical care for continued evaluation, treatment, and disposition by licensed medical professionals. The Battalion Aid Station provides triage, treatment, and evacuation by utilizing a team of physicians, physician assistants (PA), and medics who determine whether an individual is fit to return to duty (RTD), or requires stabilization and evacuation to the next level of care. Individuals who are deemed requiring further intervention are quickly assessed, stabilized, and transported onward, as needed, to the next echelon of care (Level II).

3.1.2 Level II

Level II ("Echelon II") denotes care provided in facilities that provide the availability of a more advanced medical care setting with limited "in-patient" holding space while maintaining a 100% mobile footprint. Level II care is rendered at the division-level of health service support and consists of, doctrinally, the first availability of surgical resuscitation provided by highly mobile forward surgical teams that directly support combatant units in the battle space. Level II care is provided in a mobile, semi-fixed, or fixed facility. Level II medical facilities are structured depending upon the services and forces they are supporting in the combat zone, but, generally they contain basic primary care capabilities, optometry, combat operational stress control and mental health services, dental, laboratory, radiology services, and surgical capability (dependent upon available augmentation by Field Surgical Teams [US Army], Mobile Field Surgical Teams [USAF], Surgical Company or Forward Resuscitative Surgical System [USMC/USN]).

The primary purpose of the Level II facility is to provide basic primary medical care, supportive care, and initial surgical stabilization and evacuation of wounded service members to Level III as required.

3.1.3 Level III

Level III ("Echelon III") represents corps-level health service support and is the highest level of medical care available within the COMMZ and contains the highest number of inpatient beds. Many of the major specialty care services are found within the Level III facility. These facilities are typically modular in construction, thereby allowing custom configuration based upon tactical situation, required medical response and/or according to actual need. Level III (as does Level II) sometimes includes expeditionary medical facilities (USAF Expeditionary Medical Support [EMEDS basic] and/or Naval hospital ships [USNS Mercy, designated T-AH-19 and USNS Comfort, designated T-AH-20]).

Examples of full capability Level III medical facilities include

1. US Army Corps-level Combat Support Hospital or "CSH"
2. US Air Force Expeditionary Medical Support Hospital-25 or "EMEDS +25"
3. US Navy Fleet Hospital

The primary purpose of the Level III facility is to provide advanced primary, specialty, and surgical care, while serving as a patient holding hub for rehabilitation and/or preparation for evacuation out of the COMMZ to Level IV facilities via the Aeromedical Staging Facility (ASF) typically co-located with a major air head in controlled territory.

3.1.4 Level IV

Level IV ("Echelon IV") facilities are designed to provide patients requiring more intensive intervention and rehabilitation (and/or possessing special needs) with more comprehensive care aimed towards returning function and/or limiting disability. Level IV is the first echelon at which definitive surgical management is provided outside of the combat zone and is the final stage of evacuation to one of the major military ("Level V" or "Echelon V") medical centers in the United States, where definitive stabilization, reconstruction, and full rehabilitative care is delivered.

Traditionally, a level IV facility includes major components of the Field Hospital (FH) or General Hospital (GH). In some situations, an expanded capability CSH or a fixed hospital may act as a Level IV facility (e.g., Landstuhl Army Regional Medical Center [LRMC], Germany). Typically, large proportions of patients who are evacuated to Level IV are unable to return to theater and therefore are sent onward to Level V facilities in the United States. Commanders characteristically consider any Warfighter who is evacuated back to a Level IV facility as a permanent loss to the unit, regardless of the type and extent of the illness/injury. This is due to the inherent difficulties of that individual linking back up with his unit in the combat zone once he or she is recovered.

3.1.5 Level V

Level V ("Echelon V") care is conducted solely within the continental United States (CONUS). Within the United States, Walter Reed Army Medical Center (WRAMC, located in Washington, DC), Bethesda National Naval Medical Center (NNMC, Bethesda, MD), Wilford Hall Air Force Medical Center (WHAFMC, San Antonio, TX) and/or Brooke Army Medical Center (BAMC, Fort Sam Houston, TX) provide the capability to deliver definitive care to casualties generated within the COMMZ and provide the basis for sustaining such services. The Department of Defense and Department of Veterans Affairs maintain Level V medical centers and facilities specifically designated to provide Warfighters with a combination of definitive medical and surgical stabilization, surgical reconstruction, and full rehabilitative, regenerative and convalescent care.

3.2 Evolution of Warfare

3.2.1 Brief History of Conflict Involving the United States Armed Forces

The armed forces of the United States have engaged in active combat in over 10 major conflicts subsequent to the onset of hostilities during the American Revolutionary War on 19 April 1775. The nature of these conflicts has been dominated by what is termed "regular warfare," in which the majority of combatants on either side of the conflict employ characteristics and display the traits of "regular armed forces" as defined by the Third Geneva Convention of 1949 (Geneva Convention, 1949).

3.2.2 Definition of "Regular Warfare" versus "Irregular Warfare"

"Regular forces" are defined in the Third Geneva Convention using the following criteria:

1. Being commanded by a person responsible for his subordinates to a party of conflict
2. Having a fixed distinctive emblem recognizable at a distance
3. Carrying arms openly

4. Conducting operations in accordance with the laws and customs of war

Current conflicts are predominated by counterinsurgency operations within an “irregular warfare” environment marked by violent struggle among state and non-state actors for legitimacy and influence over the relevant population (Belmont, Schoenfeld, and Goodman, 2010).

“Irregular warfare” denotes a term referring to a separate category of combatants comprised of individuals who form part or parts of armed forces of a party to an armed conflict, with or without international recognition, but who do not belong to its “regular forces” nor necessarily adhere to the regular rules of warfare and/or operate beyond the bounds of their own territory (Boczek, 2005).

3.2.3 Changes in Modern Warfare and Effect on the Military

Enhancements in protective equipment and armored personnel platforms and improvements in the quality and delivery of health care (especially “point of injury” intervention), as well as casualty (CASEVAC) and aeromedical (MEDEVAC) evacuation are all believed to be responsible for the increased survivability and reduced morbidity/mortality amongst service members actively engaged in combat operations (Belmont, Goodman, Zacchilli, et al., 2008). The tradeoff in terms of improved survivability comes at a steep price in terms of increased incidence and severity of injuries due to blast phenomenon. That price includes mild to severe nervous system trauma, devastating orthopedic injuries (sometimes requiring multiple limb amputations), and the debilitating effects of mental health related issues such as post-traumatic stress disorder from experiencing the horrors of warfare.

As the existential threat of terrorism and insurgency has evolved, so has the personal threat to the members of the Warfighter community. There have been, and remain, significant second and third order effects on the military population and its veterans’ ability to access and effectively cast their ballots during the election cycle. It is therefore necessary to consider the nature of the current conflict given an ever-evolving enemy strategy – one in which the utilization of irregular warfare is marked by a predominance of ambush tactics and terrorist attacks – in discussing and understanding the genesis, distribution, treatment, rehabilitation, and consequences of injury of the modern Warfighter as applies to the needs of the wounded in accessing their right to vote.

3.2.4 The Improvised Explosive Device (IED)

Although not a new phenomenon, the Improvised Explosive Device (IED) or “roadside bomb” has been used extensively (albeit more so in recent times) in previous conflicts with devastating effects in locations worldwide. The IED has become the “weapon of choice” by insurgent forces in the current conflicts abroad and its use has played a strong role in redefining military tactics and strategy as well as in molding public perception and government policy. The term “IED” has been thrust into the forefront of the western world’s collective consciousness due as much to the effectiveness and resultant destructive qualities of IEDs as by public opinion shaped by instant, online video feeds and 24-hrs-day/365-days-year news programs depicting their devastation on combatants and non-combatants alike.

As early as World War II, German Combat Engineers (aka: “Sappers”) and Commandos used improvised explosive devices to attack and ambush advancing Allied forces so as to deny them strategic lines of communication and resupply needed to press their advance. Belarusian “partisans” such as those led by the Bielski brothers (as depicted in the 1993 book “Defiance” and made famous in the 2009 Hollywood movie of the same name) utilized command- and fuse-detonated improvised explosive devices with devastating effect against German forces in World War II (Tec, 2009). Historical estimates suggest that these partisans derailed several thousand German military rail cars and killed nearly 30,000 enemy combatants during their insurgency activities in the years of 1943 and 1944 (Belarusian State Archival Service, 2010).

Improvised explosive devices were used extensively by Vietcong “guerillas” both during the Indo-China war against the French and later on in the conflict against the United States and South Vietnamese military. Military historians suggest that these weapons (known by the colloquialism “Booby Traps”) alone accounted for upwards of 28% of all U.S. casualties. Similarly, insurgency operations against the United Kingdom’s forces in Northern Ireland by the Provisional Irish Republican Army between 1969-1979 and Sri Lankan “Tamil Tigers” rebel/insurgent forces against Sri Lankan forces and the island’s population resulted in casualty figures in excess of 3,600 (N. Ireland) and between 80,000 and 100,000 (Sri Lanka), respectively. In both of these conflicts, the IED played a major role in contributing to generation of casualties and causation of devastating wounds.

More recently, this family of weapons has been used extensively in conflicts around the globe - in Afghanistan during the Russian occupation, in Chechnya against Russian forces, against Israeli occupying forces in Lebanon following their invasion of Lebanon in 1982, and against U.S. occupying forces in Iraq, Afghanistan, and elsewhere in the current conflict abroad. Despite improved personal protective equipment (i.e., “body armor” and “advanced combat helmets”, etc.), enhanced medical resuscitation techniques, timely casualty and aeromedical evacuation, the ability and determination of the enemy to continue a pattern of widespread and ruthless employment of improvised explosive devices (IED) as a primary weapon has heralded a pattern shift within the ranks of the U.S. armed forces casualties.

This shift is demonstrated in changes to the distribution of the mechanisms of injury in battle casualties and a substantial increase in the proportion of injuries caused by explosive mechanisms (Owens, Kragh, Wenke, et al., 2008). Recent analyses have shown that in OEF/OIF 81% of all enemy contact related combat injuries were due to explosions (predominantly IED). In comparison, combat related explosive injuries incurred by U.S. forces during the Civil War, World War I, World War II, the Korean Conflict, and the conflict in Vietnam were approximately 9%, 35%, 72%, 69%, and 66%, respectively (Hardaway, 1978).

4 Needs Assessment for Recently Wounded Warriors

GTRI conducted a systematic investigation to identify, clarify, and evaluate the voting needs of injured service members. The goal of the needs assessment was to ensure that investments in voting technology and services are directed at reducing the barriers that are most consequential to the target population (thus increasing the potential for positive impact through intervention). The assessment clarified the needs of the target population and considered voting accessibility more broadly to establish the degree of commonality existing between recently injured service members and the disability community at large. Although the needs assessment considers the opinions of service members on how voting can be improved, its purpose was not to compile a list of user requests, but to establish an understanding of what currently exists, and what gaps or barriers must be addressed to reach the goal of ensuring that all may vote privately and independently. Task objectives included

1. Determining the prevalence and types of injuries sustained, and identifying the classes of individuals who are most in need of technological or procedural support in an attempt to understand the full spectrum of experiences from initial injury through recovery that might impact voting in the target population.
2. Identifying and documenting technological barriers and potential facilitators that inhibit injured service members from voting privately and without assistance. Data collection protocols were designed and site visits were performed at major military medical centers. Absentee voting at the rehabilitation and definitive care facilities was the primary focus, although other levels of care, such as care provided at a combat support hospital, were considered by inference.

The needs assessment consisted of six major activities: (1) general review of the epidemiology of casualties incurred in the current conflicts abroad, (2) review of published studies on common injuries found in service members of interest as applies to information on accessible voting, (3) “top down” analysis of injuries and associated barriers to voting, (4) develop a data collection protocol and select sites for visiting, (5) collect data from selected sites, and (6) document the facilitators and barriers to accessible voting.

4.1 Epidemiology of Current Conflicts

Note: For purposes of this discussion, analysis considers casualties (Killed in Action [KIA], Non-Hostile injury/death, and Wounded in Action [WIA]) for combat and non-combat operations incurred during Operation Enduring Freedom (07 October 2001–present), Operation Iraqi Freedom (20 March 2003–31 August 2010), and Operation New Dawn (01 September 2010–Present).

4.1.1 Operation Enduring Freedom

Current casualty figures from Operation Enduring Freedom (07 October 2001 to 17 June 2011) are listed in Table 1 below.

Table 1. Operation Enduring Freedom (OEF) U.S. Casualty Status as of 10 July 2012

U.S. Military Casualties	Total Deaths	KIA	Non-Hostile	WIA
Afghanistan Only	1,913	1,588	325	16,781
Other Locations	114	12	102	
OEF U.S. DoD Civilian Casualties	3	1	2	
Worldwide Total	2,030	1,601	429	16,781

Source: Department of Defense U.S. Military Casualties, July 2012

4.1.2 Operation Iraqi Freedom

Current casualty figures from Operation Iraqi Freedom (19 March 2003 to 31 August 2010) are listed in Table 2 below.

Table 2. Operation Iraqi Freedom (OIF) U.S. Casualty Status as of 10 July 2012

	Total Deaths	KIA	Non-Hostile	WIA
OIF U.S. Military Casualties	4,409	3,479	930	31,926
OIF U.S. DoD Civilian Casualties	13	9	4	
Totals	4,422	3,488	934	31,926

Source: Department of Defense U.S. Military Casualties, July 2012

4.1.3 Operation New Dawn

Current casualty figures from Operation New Dawn (previously called Operation Iraqi Freedom) (1 September 2010 to 31 December 2011) are listed in Table 3 below.

Table 3. Operation New Dawn (OND) U.S. Casualty Status as of 10 July 2012

	Total Deaths	KIA	Non-Hostile	WIA
OND U.S. Military Casualties	66	38	28	301
OND U.S. DoD Civilian Casualties	0	0	0	
Totals	66	38	28	301

Source: Department of Defense U.S. Military Casualties, July 2012

4.2 Literature Review

The literature review examined information documented in academic journals from broad disciplines (e.g., public policy, psychology, and industrial design), technical reports, chapters, books, and military documents related to voting technology and military medicine. The goals of the literature review were (1) to understand the information and data systems that are currently used in military medicine; (2) to identify limiting factors related to common injuries of service members; (3) to understand the current state of voting technology; (4) to document standards and guidelines that are applicable to voting technologies and facilities; and (5) to identify emerging technologies that could be utilized in military voting facilities to mitigate limiting factors. The annotated results of the literature review are located in Appendix A of this report.

4.3 Distribution of Injuries and Analysis of Associated Barriers to Voting

Historically, the distribution of injuries in conflict reflects the predominant mechanism or mechanisms of injury on the battlefield. For example, prior to the current series of conflicts abroad, the predominant mechanism of injury (Vietnam era to 1993) was caused by high velocity gunshot wounds to single body regions such as the head/neck complex, the thorax, abdomen, or extremities (Belmont, Schoenfeld, and Goodman, 2010). Early applications of personal protective equipment (i.e., steel shell construction helmets giving way to advanced fiber equipment [Kevlar] and early body armor progressing to advanced fiber and ceramic plate solutions) evolved accordingly and provided improved personal protection to these threats.

Since the onset of combat operations and their evolution to insurgency style warfare in the current theaters of conflict, the prevalence of the improvised explosive device as a “weapon of choice” and explosive injuries have become the increasingly predominant mechanism of injury. This paradigm shift has led to a redistribution of wound patterns and their downstream effects on the Warfighter and veteran population.

4.3.1 Principal Injuries by Body Region-Overview

Sample distribution of principal injuries by body region for service members injured in Operations Iraqi Freedom and Enduring Freedom between 01 Jan 2002 and 18 Jan 2007 are listed in Table 4 below. The percentages are based on 9,037 total admission (6,001 battle, 3,036 non-battle).

Note: Current injury distributions are not available or releasable due to operational considerations but are generally reflected in the relatively recent analysis of the distribution of battle and non-battle injuries (hostile and non-hostile fire related injuries) depicted below.

Table 4. OIF & OEF Principal Injuries by Body Region as of 2007

Body Region/Location	Overall	Battle Injuries	Non-Battle Injuries
Head & Neck			
OVERALL	25.1%	26.7%	22.0%
Brain	10.3%	10.5%	9.9%
Face	6.1%	6.7%	5.0%
Eye	2.4%	3.0%	1.2%
Neck	1.7%	2.4%	0.4%
Other Head	4.6%	4.2%	5.5%
Upper Extremities			
OVERALL	25.2%	23.2%	29.2%
Shoulder/Upper Arm	5.3%	6.2%	3.6%
Forearm/Elbow	6.1%	6.1%	6.0%
Other	3.0%	3.5%	2.0%
Wrist/Hand/Fingers	10.8%	7.4%	17.5%
Spine & Back			
OVERALL	4.0%	2.8%	6.4%

Torso			
OVERALL	12.2%	14.0%	8.6%
Chest	3.7%	4.4%	2.3%
Abdomen	4.8%	6.2%	2.1%
Pelvis/Urogenital	2.7%	2.5%	3.0%
Trunk	0.6%	0.4%	0.9%
Lower Back/Buttocks	0.4%	0.4%	0.3%
Lower Extremities			
OVERALL	31.6%	31.4%	32.1%
Hip	0.8%	0.6%	1.1%
Upper Leg/Thigh	3.3%	4.0%	1.9%
Knee	1.1%	0.5%	2.3%
Lower Leg/Ankle	10.8%	8.8%	14.6%
Foot/Toes	5.2%	4.7%	6.2%
Other	10.5%	12.7%	6.0%

Source: Joint Theater Trauma Registry (JTTR), Center for AMEDD Strategic Studies, OIF & OEF Soldier Principal Injuries by Body Region, June 2007

4.3.2 Common Injuries: OIF/OEF Service Members

Whereas "polytrauma" or multiple region traumatic injury is the most common form of injury in the current military conflict – the average service member wounded in OIF/OEF has 4.2 different body region injuries (Owens, Kragh, Wenke, et al., 2008) – "traumatic brain injury" (TBI) is often referred to as the "signature injury" of OIF and OEF. These types of injuries can cause a wide range of functional limitations. Other common injuries include post-traumatic stress disorder (PTSD), hearing impairments, and visual impairments. For the purposes of this report, upper body injuries, lower body injuries, vision impairment, and other bodily injuries are included under the heading of polytrauma.

Lew and colleagues (2007) studied symptoms among a sample of patients in a Polytrauma Network Site (PNS) clinic. They found that 97% of patients (N=62) had three or more post-concussion syndrome symptoms (headaches, dizziness, fatigue, irritability, concentration or memory problems, substance abuse, and heightened reactivity to stress and emotions). They also found that over 70% of patients reported sleep disturbances, hyper-arousal symptoms, mood symptoms, headaches, and cognitive complaints. Pain was a prevalent issue in this group of patients, with 97% complaining of pain. PTSD had a prevalence of 71% and cognitive disorder had a prevalence of 55%. In addition, co-occurrence was common, with 42% of patients having diagnoses of both PTSD and cognitive disorder. Fifty-two percent of patients had significant depressive symptoms and all of those patients also had a diagnosis of PTSD. Fifty-eight percent of patients complained of tinnitus (i.e., ringing of the ears), 44% complained of difficulty with hearing, and 35% failed the hearing screening test. Seventy-five percent of patients self-reported vision problems, including photosensitivity (59%). Oculo-motor problems were found in 70% of patients. Lastly, 59% of patients reported reading problems that began after their concussive injury.

4.3.2.1 Traumatic Brain Injury

One of the most prevalent injuries emerging within OEF/OIF service members is TBI (e.g., Doarn, McVeigh, & Poropatich, 2010; Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999). TBI is a closed or penetrating injury to the brain (French & Parkinson, 2008). More specifically, TBI is "damage to brain tissue caused by external mechanical forces, as evidenced by objective neurological findings, post-traumatic amnesia, skull fracture, or loss of consciousness because of brain trauma" (Vandenbos, 2007, p. 955). TBI is one of the most common injuries among those serving in Iraq and Afghanistan, with an estimated 15 to 20 percent of service members suffering a mild TBI during deployment (Silver, McAllister, & Arciniegas, 2009). As of 2009, it was estimated that the number of cases of TBI in combat troops was as high as 320,000. Exposure to blast (e.g., from an improvised explosive device) is a common source of TBI among service members in the current conflicts. A recent study found that 78% of service members treated at an Echelon II medical unit in Iraq had been injured by IEDs or mortars and many (47%) of these injuries involved the head (Taber, Warden, & Hurley, 2006). The authors also found that 97% of the injuries to a particular Marine unit in Iraq were due to explosions (65% IEDs, 32% mines) and the majority of these (53%) involved the head or neck.

TBI can potentially affect functioning in multiple areas, including physiology, cognition, sensation and perception, and emotion. A specific individual may experience only one or many of the possible effects of a TBI. The effects of TBI vary in intensity across individuals, and can range from very subtle to life threatening (Mount Sinai Medical Center, 2008). Thus, voting processes and technologies may pose numerous difficulties for service members with impairments related to TBI. This means that one should expect a wide variety of functional impairments related to voting ability, and that a wide range of accommodations will likely be necessary just to serve the population of service members with TBI.

4.3.2.1.1 Cognition

Individuals with a moderate-to-severe brain injury typically experience problems in basic cognitive skills, such as sustaining attention, concentrating on tasks at hand, and remembering newly learned material. They may think, speak, and solve problems more slowly (Mount Sinai Medical Center, 2008). These individuals may become confused easily when normal routines are changed or when the stimulation level from the environment increases. Their speech and language may be impaired, so they might have difficulty with word-finding problems or understanding the language of others. A major class of cognitive abilities that may be affected by TBI is referred to as executive functions (i.e., the complex processing of large amounts of intricate information that humans need to function creatively, competently, and independently as beings in a complex world). After injury, individuals with TBI may be unable to function well in their social roles because of difficulty in planning ahead, keeping track of time, coordinating complex events, making decisions based on broad input, or adapting to changes in life (Mount Sinai Medical Center, 2008). A complicating factor is that perceived cognitive deficits among post-TBI patients are also related to secondary behavioral health problems such as depression, anxiety, and PTSD (Spencer, Drag, Walker, & Bieliauskas, 2010).

4.3.2.1.2 Psychosocial Health

With TBI, the systems in the brain that control social and emotional behaviors are often damaged; thus, personality can be substantially or subtly modified following injury. Common psychosocial health problems following TBI include depression, anxiety, lack of energy, decreased social contact, and lack of social integration (McCarthy et al., 2006). TBI can also result in dependent behaviors, emotional swings, lack of motivation, irritability, aggression, lethargy, being very uninhibited, or being unable to modify behavior to fit varying situations (Mount Sinai Medical Center, 2008). One study found that 29% of a sample of adults with TBI had poor psychosocial health one year after injury (McCarthy et al., 2006). The domains of psychosocial health that were impacted most severely were vitality; role limitations at work, home, or school due to emotional problems; and social functioning (McCarthy et al., 2006). Temkin, Corrigan, Dikmen, and Machamer (2009) also found that TBI adversely affects leisure and recreation, social relationships, functional status, quality of life, and independent living. Individuals who sustain a TBI are at increased risk for developing a psychiatric disorder, such as depression or a panic disorder (McCarthy et al., 2006). Another important change that affects many people with TBI is referred to as denial and occurs when the individual becomes unable to compare post-injury behavior and abilities with pre-injury behavior and abilities. For these individuals, the effects of TBI are simply not perceived - whether for emotional reasons, as a means of avoiding the pain of fully facing the consequences of injury, or for neurological reasons, in which brain damage itself limits the individual's ability to step back, compare, evaluate differences, and reach a conclusion based on that process (Mount Sinai Medical Center, 2008).

4.3.2.1.3 Sensation and Perception

Sensation and perception may also be affected by TBI. Vision may be affected in many ways, including loss of vision, blurred visual images, inability to track visual material, loss of parts of the field of vision, reduced depth perception, and sometimes disconnection between visual perception and visual comprehension, so that the person does not know what he or she is seeing (Mount Sinai Medical Center, 2008). Changes also may occur in the senses of hearing, smell, taste, and touch and the individual may become overly sensitive or insensitive in one or more of the senses. Some patients will have dual sensory impairment, meaning that they have impairments in both vision and hearing. One study found that patients with blast-related TBI are more likely than the traditional VA population to suffer from dual sensory impairment (Lew et al., 2009). The authors suggest that this premature impairment of visual and hearing functions is an alarming trend among this generation of veterans and will likely have long-term consequences. This study also found that having dual sensory impairment was negatively related to functional gain during the inpatient period, suggesting that dual sensory impairment reduces or impedes functional recovery.

4.3.2.1.4 Physiology

Following TBI, an individual may have difficulty sensing the location of his/her own body in space. Individuals with TBI may have recurring problems with balance, vertigo, and ringing in the ears. Some individuals experience seizures. If motor areas of the brain are damaged, an individual with TBI may experience varying degrees of physical paralysis or spasticity, affecting a wide variety of behavior from speech production to walking. Damage to brain tissue can also evidence itself in chronic pain, including headaches. Also, evidence is growing that hormonal, endocrine, and other body systems are affected by the brain injury. Consequently, the individual may lose control of bowel and bladder functions, sleep poorly, fatigue easily, lose appetite for food or be unable to control eating, experience menstrual difficulties, or be unable to regulate body temperature within normal boundaries (Mount Sinai Medical Center, 2008).

4.3.2.2 Post-Traumatic Stress Disorder (PTSD)

Another injury that has historically and significantly affected service members is post-traumatic stress disorder (PTSD) (Doarn, McVeigh, & Poropatich, 2010; Lew et al., 2007). PTSD is increasingly being found in returning OIF and OEF combat troops. In order to be diagnosed with full PTSD, individuals must exhibit symptoms of three different types: (a) re-experiencing of the trauma; (b) avoidance of thoughts or acts resembling the trauma with possible emotional numbing; and (c) hyperarousal symptoms (Pyne & Gevirtz, 2009). These symptoms may include distressing thoughts or dreams, avoidance behavior, sleep problems, increased arousal, agitation, irritability, difficulty concentrating, or startling (American Psychiatric Association (*DSM-IV-TR*), 2000). The hyperarousal symptoms, which include insomnia, hypervigilance, and increased startle response, seem to play a prominent role in the acute phase of trauma response, and greater hyperarousal is associated with a more chronic course over time (Schell, Marshall, & Jaycox, 2004).

While not appearing as an overt physical injury, trauma of a psychological nature is often as debilitating and presents with a variety of symptoms that could significantly affect the ability to engage in the voting process. Symptoms of PTSD and symptoms of TBI can often be confused or interrelated, making treatment and rehabilitative planning a challenge. Individuals may also experience some symptoms of PTSD, but not enough to obtain an official clinical diagnosis (i.e., sub-threshold PTSD). This means that a significant number of service members may be affected by limitations associated with PTSD, but in the absence of a PTSD diagnosis, they or others may be unaware of the extent of these limitations.

Unfortunately, those who are sub-threshold for PTSD (that is, not meeting full diagnostic criteria but experiencing some symptoms) may still experience significant life problems as a result of those symptoms. Sub-threshold PTSD has been linked to alcoholism, depression, and poor overall health (Yarvis & Schiess, 2008), as well as anger, hostility, and aggression (Jakupcak et al., 2007). Further, evidence for increased suicidality in sub-threshold PTSD has been suggested (Marshall, Olfson, Hellman, Blanco, Guardina, & Struening, 2001).

4.3.2.3 Polytrauma

Polytrauma is defined as “concurrent injury to the brain and several body areas or organ systems that results in physical, cognitive, and psychosocial impairments” (Lew et al., 2007, pg. 1028). Polytrauma often involves TBI and other disabling conditions such as orthopedic injuries, soft-tissue damage, injury to the visual or auditory system, spinal cord injury (SCI), or damage to vital systems. Polytrauma patients often experience post-concussion symptoms, PTSD, poor cognitive performance, head and back pain, auditory and visual symptoms, and problems with dizziness or balance (Lew et al., 2007). As with TBI, polytrauma often results from blast injuries inflicted by IEDs. Individuals with polytrauma are also at high risk for psychological problems, such as PTSD, given the gravity and circumstance of their injury. Because more service members are surviving injuries in the current conflicts, they are often living with injuries from multiple traumas, which can lead to long-term functional consequences. However, advances in technology (such as in prosthetics) are increasing the range of activities possible for patients who are able to access and utilize it.

Patients with polytrauma often face multiple problems during their rehabilitation, including not only physical impairment, but also social, emotional, and economic issues (Zelle, Marcantonio, & Tarkin, 2010). These patients often have long term functional limitations, particularly if their injuries include limb amputations, vision and/or hearing loss, TBI, or other injuries that physically limit their mobility. Inability to perform activities of daily living, including returning to work and participating in sports or other hobbies may impede a feeling of independence and a positive outlook on life in general. Pain management has recently become a topic of research in the area of polytrauma, due to the extent of injuries and multiple surgeries that are necessary to assist the patient in recovery.

Data on physical limitations was collected from service members who sustained combat injuries. These injuries included loss of vision, hearing, spinal cord injuries, loss of appendages, and/or damage to vital systems. Data was also collected from service members who sustained non-combat injuries (through means other than IEDs), such as burns, gunshot wounds, and injuries resulting from crushing forces, such as car accidents or direct impact from an object. People with polytrauma often accommodate to their new environment using wheelchairs and other assistive devices. However, recovery is dependent on both the combination of injuries sustained and the individual's mental well-being. If a patient has a positive, upbeat attitude, they are often more determined to push through rehabilitation with positive outcomes than someone who is depressed about their physical and/or cognitive limitations. A negative attitude often results in poor performance during rehabilitation, leading to a less successful rehabilitation process.

While injuries to the head and neck during Operations Iraqi and Enduring Freedom have increased compared to prior conflicts, injuries to the chest and abdomen injuries have decreased (Belmont, Goodman, Zacchilli, et al., 2008, and Owens, Kragh, Wenke, et al., 2008). As a testament to the effectiveness of personal protective "body armor" thoracic wounds have decreased to historically low levels (approximately 5 to 7.5%) amongst U.S. service members (Owens, Kragh, Wenke, et al., 2008). Conversely, the rates of polytrauma wounding have increased proportionately amongst U.S. service members injured by enemy fires in current combat operations. Given the devastating effects of explosives utilized in IEDs and the enhanced protective effects of personal body armor systems, rates of head/neck, face/eye, and extremity injuries resulting in traumatic and/or requiring surgical amputation of upper and lower extremities has seen a significant rise.

4.3.2.3.1 Amputation/Traumatic Amputation

Figures representing counts of amputations by service for Operations Iraqi Freedom, Enduring Freedom, and other unaffiliated conflicts from 2001 to present are listed in Table 5 below.

Table 5. Counts of Individuals with Amputations by Service by OIF, OEF, and Unaffiliated Conflicts, 2001 to September 2010

Theater	Type of Amputation	Army	Marine	Navy	Air Force	Other	Total
OIF	Major Limb	620	158	18	8	8	812
	Partial	272	49	7	11	3	342
OEF	Major Limb	145	53	5	6	4	213
	Partial	24	6	0	2	0	32
Unaffiliated Conflicts	Major Limb	94	12	25	31	26	188
	Partial	20	1	2	1	1	25
Total		1,175	279	57	59	42	1,612

Source: U.S. Military Casualty Statistics: Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom, 28 Sep 2010

4.3.3 Voting Accessibility

The accessibility of the voting process is flawed in several aspects, including the accessibility of the physical space, the design of ballots, and the technology used in the voting process.

4.3.3.1 Physical Space Accessibility

Numerous government documents provide guidelines for ensuring the accessibility of the physical space for individuals with lower mobility impairments and visual impairments (e.g., United States Department of Justice, 2004; Voting Systems Standards, 2010). Despite these resources, a study by the United States Government Accountability Office (GAO) (2009) found that physical spaces are not 100% accessible to people with disabilities, and that people with disabilities are more likely to experience difficulties with the physical space than others. Based on observations made in 2008 when the research for the GAO report was conducted, only 27% of physical spaces associated with voting have no potential impediments to voters with disabilities (up from 16% in 2000). Improving the accessibility of physical spaces is hindered due to the limited number of already existing accessible buildings that can be used for elections and the costs associated with modifying buildings. While polling places are not a primary consideration for the preparation and completion of an absentee ballot, the physical space where the voter resides and the location of key enabling technologies is a critical concern. Lessons learned from the design of accessible polling places can be directly applied to improving the voting experience for military voting.

4.3.3.2 Ballot Design

Norden, Kimball, Quesenbery, and Chen (2008) reported thirteen design problems with ballots, including inconsistency in format and style, splitting candidates for the same office onto different pages or columns, placing different contests on the same touchscreen, and placing response options on both sides of candidate names. The authors note that “poor ballot design frustrates voters, undermines confidence in the electoral process, and contributes to related Election Day problems” (p. 8). Other issues with the design of ballots include legibility and readability, the organization of information (Roth, 1998), and inconsistent terminology (Bederson & Sherman, 2002). Attempts to improve ballot design may be hindered by state laws that prescribe ballot design and make it difficult to enact improvements to the presentation of data on ballots.

4.3.3.3 Voting Technologies

The way in which ballots are displayed to voters and the ways in which the voters mark ballots have evolved, especially since the 2000 federal elections. More traditional forms include punch card ballots and optical scanning systems. In punch card systems, voters punch holes in the ballot card with a supplied punching device to indicate their choices. These systems are rarely used anymore. Individuals with dexterity impairments may have difficulty pinpointing the punching device and may not be able to apply the necessary amount of force to punch holes. Individuals with visual impairments may also have difficulty pinpointing the punching device and reading the text on the ballot (United States General Accounting Office, 2001).

Optical scan voting systems are electronic systems that use an optical scanner to read marked paper ballots and tally the voting results. An electronic ballot marker or ballot marking device is an electronic device that can help voters with disabilities mark their ballots. Additionally, these devices allow for audio interfaces along with the paper ballot. The two most common forms of optical scan ballots are the bubble ballot and the arrow ballot. The bubble ballot requires voters to completely fill in an oval, and the arrow ballot requires voters to complete an arrow (i.e., fill in the missing midsection of the arrow). Research studies have shown that users prefer the bubble ballot over the arrow ballot (Byrne, Greene, & Everett, 2007). One issue with optical scanning systems is that individuals with dexterity impairments may find it difficult to grasp and control the marking device (such as a pencil) while avoiding stray marks that may result in an undervote or an overvote (United States General Accounting Office, 2001).

Many polling places have adopted direct recording electronic (DRE) voting machines in recent years. DRE machines display ballots on an electronic display, and voters typically input their selections via mechanical buttons or by touching controls on a touchscreen. Votes are recorded electronically, and a paper audit trail may or may not be generated. DREs are able to incorporate a large range of assistive technologies for voters with disabilities, such as audio output and alternative input devices including sip and puff technology and foot pedals, facilitating anonymous voting for these individuals. Additionally, a single DRE machine can display ballots in more than one language and with a variety of formatting options (large print, high contrast, etc.). DREs can also provide error checking, to provide feedback to users to help prevent undervoting or overvoting. However, individuals with certain disabilities may not be able to use DRE machines if the assistive technologies they need are not available.

Technologies or devices designed to facilitate the submission of an absentee ballot are expected to have considerable overlap with voting machines currently being utilized in mainstream elections. Lessons learned about the design of accessible DREs can be applied to the design of equipment used by military voters.

4.3.4 Gaps in Knowledge

One knowledge gap that became apparent during the course of the literature review was in the area of limitations due to TBI. The rise in TBI incidence is due in part to the particular weaponry encountered in

OEF/OIF, but also because more service members are surviving past the injuring event now than in previous conflicts as a result of advances in trauma medicine and evacuation capabilities. Research suggests that TBI as the result of a blast injury (such as an IED) differs from TBI as a result of impact (e.g., vehicle accidents). As a result, TBI in the military population is relatively complex and poorly understood. Given this limitation, it was determined that a disproportionate amount of data would need to be collected from this injury group as compared to other injury groups on which more disability research has been conducted.

Another knowledge gap related to specific injury is in how to design voting accommodations for those service members with psychological injuries such as PTSD. Accommodations for this population may take the form of online, telephone, or mobile voting systems that can be accessed from home or another location where the individual is psychologically comfortable. Mobile application development is becoming more prevalent for other contexts, but the use of mobile applications for voting has not been examined sufficiently.

4.4 Patient Interviews

A protocol was designed to expose existing barriers and the critical gaps that must be overcome to facilitate independent and private voting by service members who have recently sustained injury. The protocol was developed using information gained from the literature review and discussions with subject matter experts. The interview protocol was pilot tested via face-to-face interviews with volunteers from treatment facilities that were likely candidates for final data collection.

Multiple centers treating wounded service members were visited to collect data. Each site was characterized and selected based on relevant criteria such as specialized care offered, patient volume, patient characteristics, and typical injuries sustained. The goal of site selection was to identify the smallest number of sites providing a reasonable cross section of the target population in addition to the types of voting procedures in place. Interviews were conducted at the following sites:

- Brooke Army Medical Center, San Antonio, TX
- Carl R. Darnall Army Medical Center, Fort Hood, TX
- National Navy Medical Center (NNMC), Bethesda, MD
- Walter Reed Army Medical Center (WRAMC), Washington, D.C.
- Womack Army Medical Center, Fort Bragg, Fayetteville, NC
- Naval Hospital Camp Lejeune, Jacksonville, NC
- Shepherd Center, Atlanta, GA

Site approval and Georgia Institute of Technology Institutional Review Board (IRB) approval were obtained prior to conducting these interviews. The structured interview battery that was used during these interviews was based in part on questions developed by the World Health Organization (WHO), as well as questions derived by GTRI based upon specific research questions. The structured interview battery is included in Appendix B of this report.

Data was gathered from OIF/OEF injured service members and analyzed the types of injuries sustained by service members, the rehabilitation timeline, and the incident rate for each injury type. This data assisted in prioritizing research objectives and predicting the impact of this research on recently injured service members. Data analyzed was primarily from combat injured OIF/OEF personnel, with the exception of those non-combat injured who sustained a mild TBI and above.

Wherever possible, face-to-face interviews were conducted by travelling to the approved research sites. Alternative interviews (e.g., telephone interviews) were also conducted when appropriate and necessary. Over 100 active, veteran, and transitional service members were interviewed. Subjects were chosen in coordination with site representatives. Care was taken to ensure that the subject pool represented the full diversity of needs with respect to disability types and knowledge gaps. As a result, the injury categories most represented involved combat injuries including TBI, polytrauma, and PTSD. Some non-combat TBI patients were interviewed in order to gather a robust range of data on potential limitations related to voting. The data obtained from the interviews was transcribed into individual Excel documents and then merged into a single database. The data was filtered and analyzed on several measures, including

- Type of injury (combat related, non-combat related);
- Injury category (TBI, PTSD, SCI, upper body injuries, lower body injuries, other injuries or illnesses, polytrauma);
- Cause of injury (blast related, non-blast related); and
- Time since injury (less than one year, one to two years, two to three years, three or more years).

4.4.1 Results

4.4.1.1 General

During the interview sessions at the military medical treatment facilities, it was noted that patients had to wait a very long time, in many cases up to a year, for the Medical Evaluation Board (MEB) to review and process the paperwork that allowed rehabilitation patients to either return to Active Duty or to transition from Active Duty to Veteran status. Some of the patients spent approximately one year in the treatment facility awaiting final review of their MEB paperwork. This means that military voting accommodations must not only consider the needs of patients in a wide range of physical states, but must also consider accommodations that could be feasibly implemented in a rehabilitative setting.

The following themes emerged from the data analysis:

- Reliance on technology (e.g., PDAs, prosthetics, wheelchairs)
- Avoidance of social situations and crowds
- Sensitivity to overstimulation (light, ambient noise)
- Loss of motivation
- Difficulty with memory and concentration
- Limitations in endurance (fatigue, pain)
- Hearing impairments (hearing loss and tinnitus)

4.4.1.1.1 Challenges
The most common difficulties encountered by the individuals who participated in the interviews were remembering to do important things and standing for long periods of time; a majority of the participants reported that they experience at least moderate difficulty completing these two tasks. This finding is expected since the most common injury categories were TBIs and lower body injuries; additionally, a majority of the participants were classified as polytrauma patients. Over half of the participants also reported hearing difficulties. However, several of the participants noted that their hearing problems were not due to a specific injury but rather due to exposure to loud noises as a part of their jobs.

4.4.1.1.2 Technology
All of the participants reported using a variety of technologies including computers, the internet, smart phones, regular cell phones, MP3 players, and PDAs. The difficulties associated with using these technologies are discussed in the following sections as applicable.

4.4.1.1.3 Voting
Only a few participants reported that they had previously voted or attempted to vote since becoming injured or ill. Most of those participants were successful in their attempts but still experienced some difficulty. The difficulties included confusing ballots, mobility limitations, a lack of motivation, and an aversion to crowds. Some of the participants diagnosed with PTSD reported that the greatest challenge they would face if voting today would be dealing with a crowd of people. Additionally, a lack of motivation would prevent some participants from voting. As one participant commented, getting out of bed in the morning can be a battle for an individual with PTSD.

4.4.1.2 TBI and PTSD

4.4.1.2.1 Challenges
More than half of the individuals who participated in the interviews were diagnosed with a TBI. Most of the TBIs were combat related, and several were blast related injuries. In general, participants with a TBI reported having the most difficulty with remembering to do important things and concentrating on doing something for ten minutes; a majority of the participants reported that they experience at least moderate difficulty completing these two tasks.

A majority of the participants also reported problems with vision, hearing, and communication. The most common visual problems were sensitivity to light and blurry vision. Other visual problems included issues related to muscle movement and nerve damage. The most common hearing problems were tinnitus or ringing in the ears and hearing loss. Other hearing problems included difficulty with background noise and filtering the source of sounds. The most common communication problems were difficulty with comprehension and finding the right word.

Participants with a non-blast related TBI typically reported more difficulties than participants with a blast related TBI; a larger proportion of participants with a non-blast related TBI reported difficulty completing cognitive tasks including concentrating, remembering, finding solutions, learning, and communicating. A greater proportion of participants with a non-blast related TBI also reported problems with vision. The two groups were approximately equal in the proportion of participants that reported problems with hearing. The intent of this data was not to distinguish between symptomology associated with blast versus non-blast related TBI or to make conclusions regarding symptoms themselves. Rather, the intent was to discover symptoms of either population that could reasonably affect voting activities. As the research sample was relatively modest, these results are somewhat limited in generalizability. However, the experiences of the service members with TBI who were interviewed are congruent with expectations given what is currently known about TBI symptomatology. Therefore, although ideally more interviews should be conducted with this subset of the injured population, it is worth examining the data trends found in this study as accessible voting technology is investigated.

Several of the individuals who participated in the interview were diagnosed with PTSD. Because participants were not specifically asked if they had been diagnosed with PTSD, the number of participants actually experiencing symptoms of PTSD is likely higher. The cognitive challenges associated with a TBI were very similar to PTSD; a majority of the participants reported at least moderate difficulty remembering to do important things and concentrating on something for ten minutes. The distinguishing factor between PTSD and a TBI was in the sensory limitations. Very few participants diagnosed only with PTSD and not with a TBI experienced visual impairments, whereas a majority of participants diagnosed with a TBI or with both a TBI and PTSD reported problems with their vision.

Participants diagnosed with PTSD reported problems with depression, anxiety, panic attacks, agoraphobia, irritability, and a lack of motivation. In general, participants with PTSD reported avoiding situations involving crowds of people. A few participants also mentioned that they do not like to have their backs turned to anyone for any period of time.

4.4.1.2.2 Technology

A portion of the participants diagnosed with a TBI reported some difficulty using technology. Some of the difficulties mentioned include

- Difficulty learning a new technology;
- Easily frustrated;
- Technology and interface are confusing;
- Tasks take more time to complete after being injured; and
- Sensitivity to light from the display.

One common theme among participants with a TBI was their use of mobile technology as a cognitive prosthetic. Specifically, several participants reported using the calendar and alarm functions on technology, such as PDAs or cell phones, to remind them of appointments and when to take medication. Several participants indicated that they relied on this type of technology to function in their daily lives. One participant also mentioned using a digital voice recorder to record important phone calls.

4.4.1.3 Upper Body Injuries

4.4.1.3.1 Challenges

Some of the individuals that participated in the interviews had upper body injuries (i.e., injury to one or both hands, arms, or shoulders). Most of the participants had only a single injury to their upper body.

For a small portion of the participants with an upper body injury, the injury resulted in the amputation of one or more appendages, including fingers. A majority of the participants with upper body injuries reported that they had experienced problems with their hands in the last thirty days. The problems that participants mentioned include

- Fatigue;
- Pain;
- Loss of range of motion;
- Tasks requiring the hands take longer to complete;
- Difficulty grasping objects;
- A loss of sensation or numbness; and
- A loss of dexterity and fine motor skills.

4.4.1.3.2 Technology

Some of the participants with upper body injuries reported that they experience some difficulty using technology. Specifically, several participants reported that they require more time to complete tasks when using technology, are limited in the amount of time they can spend using a technology, and have difficulty using a mouse and keyboard. Very few participants with upper body injuries explicitly stated that they use a prosthetic arm or hand. Some of the participants that did report using a prosthetic device reported that they experience difficulty using the prosthesis due to limitations in what it can be used for (i.e., it is not usually suitable for tasks requiring fine motor control).

4.4.1.4 Lower Body Injuries

A very small number of participants reported being diagnosed with a SCI, so very little information is available. Because their injuries only affected their lower body, the participants with a SCI are grouped with the participants with lower body injuries.

4.4.1.4.1 Challenges

Nearly half of the individuals who participated in the interviews had lower body injuries, making this the most common type of injury among the participants. Many of these participants had multiple injuries to their lower body. For several participants, the injury resulted in the amputation of one or more appendages, including toes. In general, participants with a lower body injury reported having the most difficulty with standing for a long period of time and walking a long distance; a majority of the participants reported that they experience at least moderate difficulty completing these two tasks.

4.4.1.4.2 Technology

A majority of the participants with lower body injuries reported using one or more types of assistive technology to aid in mobility, including prosthetic devices, wheelchairs, canes or crutches, and braces. Several of the participants reported that they experience difficulty using the assistive technology. The most common problem participants encountered was with using prosthetics. Specifically, participants reported that they had difficulty getting used to using prosthetics and that the prosthetics were painful.

4.5 Summary of Lessons Learned

Recently injured service members with a TBI, polytrauma, PTSD, or other injuries are likely to experience at least some degree of difficulty performing activities associated with voting due to physical, cognitive, and sensory limitations. These limitations include problems with memory, decision making, light and noise sensitivity, hearing loss, crowd anxiety, mobility, and dexterity. As a result of these limitations, injured military voters may be unable to perceive, understand, complete, and submit a ballot. The typical paper-and-pencil absentee ballot is not accessible to many injured military voters due to these limitations. Successfully navigating the absentee ballot requires that the disabled voter have access to accommodations matching their disability. This may not always be the case given differences in economic and community resources. Alternative forms of presenting, completing, and submitting the ballot must be investigated.

Not only do ballots need to be investigated for possible redesign to accommodate military voters with disabilities such as TBI, polytrauma , PTSD and other limiting disabilities, the process of getting the ballots to the voters needs to be evaluated as well. It was evident throughout the interview process that many of the service members were not aware of the various ways in which they could access voter registration and absentee ballot forms. Having that information readily available to all service members, whether active, transitional, or veterans in medical institutions would be a simple way to increase familiarity with the absentee ballot process. Regular reminders in the months leading up to an election would be helpful for those service members who have difficulty remembering to do things. These process improvements will be helpful, but will not, however, eliminate the issues associated with physical and cognitive limitations associated with absentee ballots. Numerous service members use innovative technologies, such as iPhones and iPads, to assist them in their daily lives, for things such as social networking, scheduling medication reminders, calendar applications, and normal computer use. Incorporating technologies such as smartphones and other mobile devices to better assist service members in the voting process appears to be a seamless way to bring voting to the military voter.

5 Key Technologies for Accessible Voting

5.1 Common Approaches

Assistive technology is any technology that is used to improve or maintain functional capabilities of people with disabilities (National Council on Disability, 2004). Assistive technologies provide enhancements to or change the method of interacting with a technology. They can be external devices or programs that provide additional functions, or they may be built into the products themselves. Wheelchairs, prosthetic limbs, hearing aids, and screen readers are all considered assistive technology.

Universal design, on the other hand, is a design process used to ensure that technology is accessible and usable to everyone, including people with disabilities. Accommodations do not have to be made for users with disabilities because the technology is already accessible. The Center for Universal Design has published seven principles for universal design:

1. Equitable Use: The design is useful and marketable to people with diverse abilities.
2. Flexibility in Use: The design accommodates a wide range of individual preferences and abilities.
3. Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue.
7. Size and Space for Approach and Use: Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

These principles should guide product design and development. Universal design must also consider the population that is expected to use the product. This population may include people with disabilities (e.g., individuals with visual, hearing, cognitive, or mobility impairments, or some combination of these) (National Council on Disability, 2004).

There is some debate over which approach, assistive technology or universal design, is the best way to incorporate accessibility into a product. An ideal solution may be that product developers attempt to integrate universal design into their products whenever possible while also ensuring compatibility with assistive technology when the universal design is not possible.

5.2 Enabling Technologies

The following recommendations are based upon data collected from the literature review on voting technology and military injuries, published military injury statistics, and results of structured interviews with active duty, transitional, and veteran service members.

5.2.1 Screen Magnifier

A screen magnifier is a software application that presents enlarged screen output on a display. The screen magnifier on a typical computer is capable of 16 times magnification, and some may be capable of 32 times magnification or more. Several of the injured service members that participated in the interviews reported visual impairments including loss of visual acuity. The voting technology should have a built-in screen magnification function capable of a wide range of magnification levels. Since visual impairment is a common symptom of TBI, other symptoms common to TBI, such as cognitive impairments, should be considered. Since injured service members with a visual impairment may also have a cognitive impairment, the screen magnifier should enlarge the entire screen rather than just a portion of it so as to not confuse the voter.

5.2.2 Adjustable Contrast and Brightness

Several of the injured service members with a TBI also reported sensitivity to light. A few participants specifically mentioned experiencing difficulty with the amount of light that is emitted from a typical computer screen. To accommodate the needs of these users, the voting technology should provide a method for adjusting the contrast and brightness of the display. This can be achieved with alternate display schemes so that, for example, the user can invert the screen colors (i.e., light characters on a dark background versus dark characters on a light background). Alternatively, the voting technology can allow users to adjust contrast and brightness independently of each other over a wide range of values.

5.2.3 Speech Output

For injured service members with more significant visual impairments who cannot view the display even with the functions previously mentioned, speech output may be necessary. Voters with cognitive impairments as a result of TBI may also benefit from speech output combined with the visual display. To ensure secure, private voting, the voting technology should include headphones with adjustable volume. Voters should have control over which part of the ballot is being read so that they can go back to previous content, pause, and skip ahead to new content.

5.2.4 Speech Recognition

Speech recognition software allows the user to operate technology such as a computer using only verbal commands. Injured service members with upper mobility impairments can benefit from this technology. Speech recognition can also be helpful for individuals with visual impairments when used in combination with speech output. However, depending on how it is implemented in voting technology, speech recognition can compromise the security of the voting process.

5.2.5 Touchscreens

A current trend in electronic voting technology is the use of touchscreen interfaces. Touchscreens may be easier to use for injured service members with upper mobility impairments compared to a standard mouse or keyboard. They may also be more user-friendly for individuals with cognitive impairments, such as service members with a TBI, because of the one-to-one mapping between the control and the display. Since the controls and display are the same and can change from one screen to the next, touchscreen technology is also useful when space is limited.

Although a touchscreen interface may improve accessibility for individuals with upper mobility impairments and cognitive impairments, it also introduces new accessibility issues for individuals with visual impairments. Since touchscreens do not provide tactile feedback like physical buttons do, injured service members with visual impairments may not be able to identify controls. Additionally, some forms of touchscreen technology may not be usable for voters with prosthetic arms or hands. Capacitive touchscreens, the most common type of touchscreen technology, detect touch based on the electrical properties of the object that is touching the screen. Certain types of objects, such as the tip of a pencil, gloved fingers, or a prosthetic arm, do not produce detectable touches. These issues should be taken into account when considering the use of touchscreens on voting devices.

5.2.6 Mobile Devices

The use of mobile technologies as a means of augmenting cognitive functionality appears to be a robust and feasible way to increase accessibility for those with cognitive limitations. Several of the recently injured service members with a TBI reported using the reminders and alerts features on current smart phone devices to remember upcoming appointments, medication dose schedule, and other important events. Considering the needs of military voters, applications could be further developed to present political candidate biographical and platform content to military voters if they are unable to gather or maintain this knowledge for themselves. This information could be presented as text, verbal narratives, or video content, and downloaded by military voters as it is needed.

5.2.7 Tracking Technology

Tracking technologies, such as eye and head tracking systems, provide the functionality of both a mouse and keyboard. The tracking technology consists of a camera that continuously tracks a user's movements. The camera may track the movement of a certain facial feature, changes in the reflection of light from the user's eyes, or the movement of a reflective dot or other device placed on the user's head or other body part. Recently injured service members who have mobility impairments can easily use this technology since it does not require hand function. Additionally, when used in combination with speech output, users with visual impairments can also successfully use the tracking technology to select options on a screen.

6 Conclusions

The needs of recently injured service members are unique to that population. The nature of injuries common to service members that have served in OEF/OIF are different from the injuries resulting in disability that are common to civilians. Accessibility research based on civilian populations can help inform the design of voting technologies for recently injured service members. However, there are gaps in this knowledge that are relevant to the injured military population, such as accommodations for individuals diagnosed with PTSD.

The most common difficulties encountered by the individuals who participated in the interviews were remembering to do important things and standing for long periods of time; a majority of the participants reported that they experience at least moderate difficulty completing these two tasks. Over half of the participants also reported difficulty hearing. All of the participants in the interviews reported using a variety of technologies including computers, the internet, smart phones, regular cell phones, MP3 players, and PDAs. The difficulties associated with using these technologies have been discussed throughout this report, but an overwhelming number of service members used technology as a way to assist them in their daily living. Table 6 contains a summary of the injuries and impairments common to recently injured service members in OIF/OEF as well as how those impairments affect the voting process.

Table 6: Impairments and Their Impact on Voting by Recently Injured Service Members.

Injury	Impairment	Impact on Voting
TBI, Other	Loss of visual acuity (including blindness)	Voters may experience difficulty with completing or be unable to complete the following tasks: • Viewing a display • Reading a ballot • Reading instructions for completing the ballot • Selecting the desired option • Reviewing the ballot before submitting it
TBI	Sensitivity to light	Voters may experience difficulty with completing or be unable to complete the following tasks: • Viewing a display that emits light • Viewing brightly colored objects such as a bright white paper ballot
TBI, Other	Hearing loss or tinnitus	Voters may experience difficulty with completing or be unable to complete the following tasks: • Hearing auditory cues (such as beeps) • Hearing speech output (from a device or the voting assistance officer)

Injury	Impairment	Impact on Voting
TBI, PTSD	Difficulty concentrating	Voters may experience difficulty with completing or be unable to complete the following tasks: • Maintaining focus on the voting process • Ignoring distracting stimuli • Keeping track of progress • Completing the ballot in a potentially limited amount of time • Paying attention to and comprehending instructions
TBI, PTSD	Memory problems	Voters may experience difficulty with completing or be unable to complete the following tasks: • Remembering to vote • Remembering and comprehending the instructions for completing the ballot • Recognizing the name of the candidate or option he/she wishes to vote for • Comprehending long passages of text • Keeping track of progress • Completing the ballot in a potentially limited amount of time
TBI	Learning new tasks	Voters may experience difficulty with completing or be unable to complete the following tasks: • Learning how to use new voting technology • For first time voters, learning about the voting process • Assembling the components of a ballot for submission
Upper body injuries, TBI, SCI, Other	Loss of dexterity and fine motor control; loss of sensation	Voters may experience difficulty with completing or be unable to complete the following tasks: • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Selecting or marking a small target (e.g., filling in a small oval) • Handling voting materials such as paper ballots, other voting paperwork, and security and mailing envelopes

Injury	Impairment	Impact on Voting
Upper body injuries, SCI, Other	Amputation requiring the use of a prosthetic hand or arm	Voters may experience difficulty with completing or be unable to complete the following tasks: • Using a touchscreen (depending on the type of touchscreen) • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Selecting or marking a small target (e.g., filling in a small oval) • Handling voting materials such as paper ballots, other voting paperwork, and security and mailing envelopes
Upper body injuries, TBI, SCI, Other	Limitations in endurance	Voters may experience difficulty with completing or be unable to complete the following tasks: • Completing lengthy ballots
Lower body injuries, TBI, SCI, Other	Loss of mobility requiring the use of a wheelchair	Voters may experience difficulty with completing or be unable to complete the following tasks: • Reaching an installed device (e.g., a voting kiosk)
Lower body injuries, upper body injuries, TBI, Other	Pain	Voters may experience difficulty with completing or be unable to complete the following tasks: • Concentrating on the voting process • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Completing lengthy ballots

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders* (Revised 4th ed.). Washington, DC: Author.

Bederson, B. B. & Sherman, R. M. (2002). Usability review of the Diebold DRE system for four counties in the state of Maryland. Retrieved November 9, 2010, from www.capc.umd.edu/rpts/MD_EVoteMach.pdf.

Belmont, P. J., Goodman, G. P., Zacchilli, M., et al. (2010). Incidence and Epidemiology of Combat Injuries Sustained During "The Surge" Portion of Operation Iraqi Freedom by a US Army Brigade Combat Team. *Journal of Trauma* (In press).

Belmont, P. J., Schoenfeld, A. J., & Goodman, G. (2010). Epidemiology of Combat Wounds in Operation Iraqi Freedom and Operation Enduring Freedom: Orthopaedic Burden of Disease. *Journal of Surgical Orthopaedic Advances. 19(1), 1-6.*

Boczek, B. A. (2005). International law: A dictionary. Lanham, Md: Scarecrow Press.

Bybee, J. S., & United States. (2002). *Status of Taliban forces under Article 4 of the Third Geneva Convention of 1949*. Washington, D.C: Office of the Assistant Attorney General.

Byrne, M. D., Greene, K. K., & Everett, S. P. (2007). *Usability of voting systems: Baselines data for paper punch cards and lever machines.* Paper presented at CHI 2007, San Jose, CA.

Clark, M. E., Bair, M. J., Buckenmaier, C. C., Gironda, R. J., & Walker, R. L. (2007). Pain and combat injuries in soldiers returning from Operations Enduring Freedom and Iraqi Freedom: Implications for research and practice. *Journal of Rehabilitation Research & Development, 44*(2), 179-194.

Colantonio, A., Ratcliff, G., Chase, S., Kelsey, S., Escobar, M., & Vernich, L. (2004). Long term outcomes after moderate to severe traumatic brain injury. *Disability and Rehabilitation, 26*(5), 253-261

Geneva Conventions. (2011). In *Encyclopædia Britannica*. Retrieved 12 June 2011, from http://www.britannica.com/EBchecked/topic/229047/Geneva-Conventions.

Doarn, C. R., McVeigh, F., & Poropatich, R. (2010). Innovative new technologies to identify and treat traumatic brain injuries: Crossover technologies and approaches between military and civilian applications. *Telemedicine and e-Health, 16*(3), 373-381.

Fisher, H. (2010). U. S. Military Casualty Statistics: Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom. Congressional Research Service, CRS Report for Congress – September 28, 2010.

French, L. M. & Parkinson, G. W. (2008). Assessing and treating veterans with traumatic brain injury. *Journal of Clinical Psychology: In Session, 64*(8), 1004-1013.

Hardaway, R. M. (1978). Vietnam would analysis. Journal of Trauma. 18:635-643.

Hetz, S. P. (2006). Introduction to military medicine: A brief overview. *Surgical Clinics of North America, 86*, 675-688.

Jakupcak, M., Conybeare, D., Phelps, L., Hunt, S., Holmes, F. A., Felker, B., . . . McFall, M. E. (2007). Anger, hostility, and aggression among Iraq and Afghanistan War veterans reporting PTSD and subthreshold PTSD. *Journal of Traumatic Stress, 20*(6), 945-954.

Kennedy , C. H. & Moore, J. L. (2010). *Military Neuropsychology*. New York: Springer.

Kruse, D. L., Schriner, K., Schure, L., & Shields, T. G. (1999). *Empowerment through civic participation: A study of the political participation of people with disabilities* (Final report to the Disability Research Consortium, Bureau of Economic Research, Rutgers University and the New Jersey Developmental Disabilities Council). New Brunswick, NJ: Rutgers University.

Lew, H. J., Poole, J. H., Vanderploeg, R. D., Goodrich, G. L., Dekelboum, S., Guillory, S. B., . . . Cifu, D. X. (2007). Program development and defining characteristics of returning military in a VA Polytrauma Network Site. *Journal of Rehabilitation Research & Development, 44*(7), 1027-1034.

Livingston, I. S., Messera, H. L., & O'Hanlon, M. (2011). *Afghanistan Index: Tracking Variables of Reconstruction & Security in Post-9/11 Afghanistan*. Brookings Institution. Retrieved July 11, 2011, from http://www.brookings.edu/~/media/Files/Programs/FP/afghanistan%20index/index.pdf.

Marshall, R. D., Olfson, M., Hellman, F., Blanco, C., & Struening, E. L. (2001). Comorbidity, impairment, and suicidality in subthreshold PTSD. *American Journal of Psychiatry, 158*(9), 1467-1473.

McCarthy, M. L., Dikmen, S. S., Langlois, J. A., Selassie, A. W., Gu, J. K., & Horner, M. D. (2006). Self-reported psychosocial health among adults with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 87,* 953-961.

Mount Sinai Medical Center (2008). What Impact Will Moderate or Severe TBI Have on a Person's Life? Retrieved December 8, 2010, from http://www.brainline.org/content/2008/07/what-impact-will-moderate-or-severe-tbi-have-persons-life.html.

Norden, L., Kimball, D., Quesenbery, W., & Chen, M. (2008). *Better ballots*. New York: New York University School of Law, The Brennan Center for Justice.

O'Hanlon, M. & Livingston, I. S. (2011). *Iraq Index: Tracking Variables of Reconstruction & Security in Post-Saddam Iraq*. Brookings Institution. Retrieved July 11, 2011, from http://www.brookings.edu/~/media/Files/Centers/Saban/Iraq%20Index/index.pdf.

Owens, B. D., Kragh, J. F., Wenke, J. C., et al.(2008). Combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom. *Journal of Trauma*. 64:295-229.

Pyne, J. M. & Gevirtz, R. (2009). Psychophysiologic assessment and combat post traumatic stress disorder. *Biofeedback, 37*(1), 18-23.

Roth, S. K. (1998). Disenfranchised by design: Voting systems and the election process. *Information Design Journal, 9*(1), 29-38.

Schell, T. L., Marshall, G. N., & Jaycox, L. H. (2004). All symptoms are not created equal: The prominent role of hyperarousal in the natural course of posttraumatic psychological distress. *Journal of Abnormal Psychology, 113,* 189-197.

Silver, J. M., McAllister, T. W., & Arciniegas, D. B. (2009). Depression and cognitive complaints following mild traumatic brain injury. *American Journal of Psychiatry, 166*(6), 653-661.

Spencer, R. J., Drag, L. L., Walker, S. J., & Bieliauskas, L. A. (2010). Self-reported cognitive symptoms following mild traumatic brain injury are poorly associated with neuropsychological performance in OIF/OEF veterans. *Journal of Rehabilitation Research & Development, 47*(6), 521-530.

State Archival Service. "Historical background". World War Two. Republic of Belarus, Ministry of Justice, Department of Archives and Records Management. Retrieved 13 June 2010, from http://www.archives.gov.by/eng/index.php?id=104476.

Taber, K. H., Warden, D. L., & Hurley, R. A. (2006). Blast-related traumatic brain injury: What is known? *The Journal of Neuropsychiatry and Clinical Neurosciences, 18*(2), 141-145.

Tec, N. (2009). Defiance. New York: Oxford University Press.

Temkin, N. R., Corrigan, J. D., Dikmen, S. S., & Machamer, J. (2009). Social functioning after traumatic brain injury. *Journal of Head Trauma Rehabilitation, 24*(6), 460-467.

Thurman, D. J., Alverson, C., Dunn, K. A., Guerrero, J., & Sniezek, J. E. (1999). Traumatic brain injury in the United States: A public health perspective. *The Journal of Head Trauma Rehabilitation, 14*(6), 602-615.

United States Army Center for AMEDD Strategic Studies. (2007). OIF & OEF Soldier Principal Injuries by Body Region. Joint Theater Trauma Registry, June 2007.

United States Department of Defense. (2012). U.S. Casualty Status for OIF, OND, and OEF. Retrieved July 10, 2012, from http://www.defense.gov/news/casualty.pdf.

United States Election Assistance Commission. (2005). Voluntary Voting System Guidelines Version 1.0. Retrieved May 27, 2011, from http://www.eac.gov/testing_and_certification/voluntary_voting_system_guidelines.aspx.

United States Election Assistance Commission. (2009). Polling Place Accessibility. Retrieved May 27, 2011, from http://www.youtube.com/user/helpamericavote#p/u/2/PgzvuYGVLEw.

United States Election Assistance Commission. (2010). Accessibility. In *Election management guidelines* (chap. 19). Retrieved May 27, 2011, from http://www.eac.gov/assets/1/Documents/EMG%20chapt%2019%20august%2026%202010.pdf.

United States Government Accountability Office. (2001). *Voters with disabilities: Access to Polling Places and alternative voting methods* (Publication No. GAO-02-107). Washington, DC: U.S. Government Printing Office.

United States Government Accountability Office. (2009). *Voters with disabilities: More Polling Places had no potential impediments than in 2000, but challenges remain* (Publication No. GAO-09-685). Washington, DC: U.S. Government Printing Office.

Vandenbos, G. R. (Ed.). (2007). *The APA dictionary of psychology*. Washington, DC: American Psychological Association.

Vanderheiden, G. C. (2004). Using extended and enhanced usability (EEU) to provide access to mainstream electronic voting machines. *Information Technology and Disabilities, X*(2). Retrieved March 14, 2011, from http://trace.wisc.edu/docs/2005-EEU-voting/.

Weathers, F., Litz, B., Herman, D., Huska, J., & Keane, T. (October 1993). *The PTSD Checklist (PCL): Reliability, Validity, and Diagnostic Utility.* Paper presented at the Annual Convention of the International Society for Traumatic Stress Studies, San Antonio, TX.

Xydakis, M. S., Fravell, M. D., Nasser, K. E., & Casler, J. D. (2005). Analysis of battlefield head and neck injuries in Iraq and Afghanistan. *Otolaryngology - Head and Neck Surgery, 133*, 497-504.

Yarvis, J. S. & Schiess, L. (2008). Subthreshold PTSD as a predictor of depression, alcohol use, and health problems in soldiers. *Journal of Workplace Behavioral Health, 23*(4), 395-424.

Zelle, B. A., Marcantonio, A., & Tarkin, I. S. (2010). Functional long term outcomes in poly-trauma patients with orthopedic injuries. In H. C. Pape, A. Peitzman, C. W. Schwab, & P. V. Giannoudis (Eds.), *Damage control management in the poly-trauma patient* (pp. 439-451). New York: Springer.

Appendix A: Annotated Literature Review Results

Accessibility of Voting Systems

Appelbaum, P. S. (2000). “I vote. I count”: Mental Disability and the right to vote. *Psychiatric Services, 51*(7),849-850.

> Despite advances in suffrage rights for other groups, individuals with mental disabilities still experience significant barriers to voting. The authors discuss nationwide considerations of mental fitness for voting. With advances in technology, the mental requirements for voting are constantly changing. For example, some modern voting machines do not require voters to be able to read, because the machine can read to the voter. Legislatures should keep pace with technological advances and societal sentiments.

Bundy, H. (2003). Election reform, polling place accessibility, and the voting right of the disabled. *Election Law Journal, 2*(2),849-850.

> Historically, much of the focus on improving voting accessibility has been directed towards issues of polling place accessibility, while voting machine accessibility has received less attention. Despite this insight, the paper mostly addresses physical accessibility issues and associated laws and litigation. Special attention is given to the Help America Vote Act (HAVA) of 2002. Although HAVA omits many significant accessibility requirements, it explicitly references previous laws that cover those requirements.

Election Assistance Commission (2010). Election Management Guidelines, Chapter 19: Accessibility.

> This chapter on voting accessibility provides many examples of ways to improve accessibility. Recommendations for how to incorporate these good practices into all aspects of election administration are provided. The chapter recommends that election officials seek assistance from community groups that support individuals with disabilities. This is a unique source of recommendations for appropriate behavior by poll workers as they interact with disabled voters, and the authors recommend specific training for this purpose. This is also one of the few sources that discuss the accessibility of mail-in ballots; it described a system whereby voters complete a ballot on their home computer (which is accessible), print the ballot, and mail it in.

Goler, J. A., Selker, E. J., & Wilde, L. F. (2006). *Augmenting voting interfaces to improve accessibility and performance.* Paper presented at the CHI 2006 Workshop, Montreal, Canada.

> Approximately one in seven voters is reading disabled (RD). The error rates between RD voters and non-RD voters using current voting technologies differ considerably. Previous research has indicated that RD voters are less likely to make errors when voting using a full-faced screen whereas non-RD voters are less likely to make errors when voting using a page-by-page system. The Low Error Voting Interface (LEVI) was created in an effort to improve performance for all

voters. The next goal for the Caltech/MIT voting technology project is to improve the LEVI for RD voters.

Human-Centered Computing Lab, Clemson University (n.d.). Prime III. Retrieved from http://www.primevotingsystem.com/.

The Human Centered Computing Lab at Clemson claims that the electronic voting system (Prime III) developed by the lab is the world's most accessible voting system. The key to the system to visibility is its multimodal interface and easy to use design that can accommodate users with a wide variety of disabilities. Assistance is only required at the beginning of the voting process, when a poll worker initiates the voting session. Voters can interact with the system by touch or voice, via a touchscreen or microphone, respectively. Ballot information is provided visually and audibly. When an audio-speech interface is used, the order of candidate names is randomized so that voter privacy is ensured.

Keller, A. M., Dechert, A., Auerbach, K., Mertz, D., Pearl, A., & Hall, J. L. (2005). *A PC-based open-source voting machine with an accessible voter-verifiable paper ballot.* Paper presented at USENIX '05, Anaheim, CA.

A variety of social, practical, and economic considerations are pushing a patron to tour the adoption of computerized voting systems in lieu of mechanical systems. In general, computerized voting systems provide more opportunity than mechanical systems for accommodating voters with disabilities. However, most computerized voting systems do not provide a voter-verifiable paper audit trail (VVPAT). A solution is to simply create a computerized voting system that provides the voter with a printout of the voted ballot, which the voter can then take to a separate machine for verification. This dual-system design reduces susceptibility to malicious tampering. This is one of the few solutions available for providing a VVPAT to blind voters.

Kruse, D. L., Schriner, K., Schur, L., & Shields, R. (1999). A study of the political behavior of people with disabilities, what determines voter turnout. Executive Summary: Empowerment through Civic Participation. Final Report to the Disability Research Consortium Bureau of Economic Research, Rutgers University and New Jersey Developmental Disabilities Council. Retrieved from http://www.independentliving.org/docs5/disvoters.html.

This study conducted a telephone survey containing general questions about voting, including difficulties at the polling place, with transportation, and abilities. The results indicated that people with disabilities were more likely to experience difficulties at the polling place than those who did not have disabilities, and that this differentially affects voter turnout for the two groups. The study concluded that greater attention needed to be given to accessibility at the polling place.

Roth, S. K. (1998). Disenfranchised by design: Voting systems and the election process. *Information Design Journal, 9*(1), 29-38.

This is considered one of the seminal papers on voting accessibility, and one of very few papers on the topic written before the 2000 election. It discusses the evaluation of voting systems from the human factors perspective. Although it deals with a somewhat outdated electronic voting system, its methods and the accessibility concerns it raises are still relevant today. The organization and format of ballots can raise accessibility issues, regardless of the type of technology upon which the ballot is displayed.

Roth, S. K. (n.d.). Human factors research on voting machines and ballot designs: An exploratory study.

This paper provides historical overview of voting technologies and associated usability issues up to and including the U.S. elections in 2000. After summarizing a number of usability issues associated with systems used historically, the author proposes that the ease of use of future voting technologies be assessed according to six criteria, including: ease of use; accessibility to voters with disabilities; information design; reduction of user error; reduction of intentional under voting; and time required to vote.

Selker, E. J., Goler, J. A., & Wilde, L. F. (2005). Who does better with a big interface? Improving voting performance of reading disabled voters. Unpublished manuscript.

Three electronic voting systems were compared to examine how different voting systems affect the performance of voters with reading disabilities. Two of the systems were full-faced systems where all races and selections are displayed simultaneously. The third system was a touchscreen system where only a few races are presented on each screen. The authors found that voters with a diagnosed reading disability performed worse on the touchscreen system and better on the full-faced systems than did the control group. Voters who had not previously been diagnosed with a reading disorder but performed poorly on the reading test had the largest number of errors for all three systems. The results suggest that individuals with known reading disabilities have learned coping techniques that allow them to interact effectively with the full-faced system. Individuals with undiagnosed reading disabilities have not learned these coping techniques, so they were the most error-prone for all three systems. The authors suggest that a hybrid design incorporating the advantages of both systems will be beneficial to all users.

Smith, B., Laskowski, S., & Lowry, S. (2009). *Implications of graphics on usability and accessibility for the voter.* Paper presented at E-Voting and Identity: Second International Conference, Luxembourg.

The use of graphical elements, such as icons, thereof, and alerts symbols, raise usability and accessibility issues. Certain types of graphical elements may enhance usability for individuals with disabilities. For example, graphical elements might be particularly beneficial for voters who have low reading ability. Also, animations might be beneficial for conveying instructions. However, empirical studies are needed to validate these conclusions.

The Ragged Edge. (2000). Voters with disabilities face discrimination nationwide. Retrieved from http://www.raggededgemagazine.com/1100/1100votestory.htm.

This article gives some specific anecdotes related to barriers to accessible voting. People describe inaccessible polling places and barriers to voting in private.

Trace Center, University of Wisconsin-Madison. (2008). Voting accessibility. Retrieved from http://trace.wisc.edu/voting/.

The Trace Center researches accessible voting. They created the EZ Access keypad, which helps make voting machines more accessible. This website provides presentations and publications by the Trace Center on voting accessibility.

United States General Accounting Office. (2001). *Voters with disabilities: Access to Polling Places and alternative voting methods.* Washington, DC: GAO.

This report was produced prior to the passing of the Help America Vote Act of 2002, and many of its findings were used to guide that Act. For instances in which an accessible voting place is not available, alternative methods for voting are suggested. These include options such as curbside polling, absentee voting, and Internet voting. Advantages and disadvantages associated with each alternative method are discussed.

Vanderheiden, G. C. (2004). Using extended and enhanced usability (EEU) to provide access to mainstream electronic voting machines. Information Technology and Disabilities, X(2), retrieved from http://trace.wisc.edu/docs/2005-EEU-voting/.

Many precincts offer two types of voting machines: a "normal" machine and an accessible machine. Some voters, such as older adults and recently injured individuals, may not realize that they need an accessible voting machine. If they attempt to use an inaccessible voting machine, they will experience difficulty. A solution to this problem is to employ a single type of voting machine that is accessible to all users. The authors conducted a series of usability and prototypes studies to identify possible solutions. The EZ Access keypad, developed by the University of Wisconsin, is a promising solution. It is a simple, wired controller that can be plugged into a voting machine. A system that employs an EZ Access keypad, speech input, and audio output could be highly accessible.

Usability of Voting Systems

Arzt-Mergemeier, J., Beiss, W., & Steffens, T. (2007). *The digital voting pen at the Hamburg Elections 2008: Electronic voting closest to conventional voting.* Paper presented at The International Conference on E-voting and Identity, Bochum, Germany.

The city of Hamburg revised its election laws so that each voter has more than one vote making the voting process more complicated. Tallying all of the votes would be complicated and time consuming using traditional ballots, so an electronic voting system called the Digital Voting Pen System ("Digitales Wahlstift-System", or DWS) is proposed. The DWS was selected due to its security, verifiability, and closeness to the conventional voting procedure and therefore its acceptance among voters. The digital pen is used like an ordinary pen but contains a microprocessor that scans the marks the user places on a special piece of paper with a specific dot pattern printed in the background. The paper booklet is collected along with the electronic vote for spot tests or, as needed, in depth verification of polling results.

Bederson, B. B., Lee, B., Sherman, R. M., Herrnson, P. S., & Niemi, R. G. (2003). *Electronic voting system usability issues.* Paper presented at the SIGCHI conference on Human Factors in Computing Systems, Ft. Lauderdale, FL.

Usability problems associated with paper and mechanical voting devices were brought to the public eye after the elections of 2000. In response, many precincts nationwide have begun to use electronic voting machines. However, electronic voting machines have usability problems as well. This paper discusses benefits and drawbacks of both kinds of voting machines, as well as the issue of technology acceptance by different demographic groups. Some groups, such as older adults and those of lower socioeconomic status, are less familiar with electronic devices, and may therefore less readily accept the new technology. They also may experience significantly more difficulty when using the new technology.

Bederson, B. B. & Sherman, R. M. (2002). Usability review of the Diebold DRE system for four counties in the state of Maryland. Retrieved from www.capc.umd.edu/rpts/MD_EVoteMach.pdf.

The results of a usability evaluation of the Diebold AccuVote-TS voting system are reported. The system, a direct reported electronic voting system, was evaluated using three methods: expert review, close-up observation, and field testing. The system exhibited both strength and weaknesses. Some of the weaknesses included the absence of a dedicated help button, unclear and long help instructions, and inconsistent terminology. Although most of the users responded favorably to the system, some users did report a need for improvements.

Byrne, M. D., Greene, K. K., & Everett, S. P. (2007). *Usability of voting systems: Baselines data for paper punch cards, and lever machines.* Paper presented at CHI 2007, San Jose, CA.

Computer-based direct recording electronic (DRE) voting systems are being adopted by jurisdictions in the United States to replace older technologies such as paper ballots, punch cards, and lever machines. The computer-based DRE systems could potentially improve the usability and accessibility of the voting process, but the only way to know if these systems do improve usability is to have baseline data on the usability of the older technologies. The authors performed an experiment to assess the usability of punch cards, lever machines, and two forms of paper ballots (a bubble ballot and an arrow ballot). They found that while there was no significant difference in the amount of time required to complete the ballots, the four methods did vary in error rates with users making the fewest errors when using paper ballots. Additionally, the bubble ballot was seen as the most usable by individuals who participated in the study.

Campbell, B. A. & Byrne, M. D. (2009). *Now do voters notice review screen anomalies? A look at voting system usability.* Paper presented at the 2009 Electronic Voting Technology Workshop / Workshop on Trustworthy Elections, Montreal, Canada.

> The research summarized in this article builds on previous research indicating that approximately two thirds of voters do not notice discrepancies between the review screen on an electronic voting machine and the selections they intended. In the previous study, the instructions did not emphasize to voters the need for verification. The current study improved the instructions by explicitly instructing voters to review their choices before casting their ballot. Additionally, the review screen was redesigned so that it included party information and made undervotes more visually salient. The changes made to the instructions and interface did increase the detection rate but only moderately to 50%.

Conrad, F. G. (n.d.). Usability and voting technology. White paper for Voting Technology Workshop.

> Usability testing assesses speed, accuracy, and user satisfaction. It has a long history of use and domains other than voting technology. Lessons learned from these other domains should be applied to the assessment of emerging voting technologies. Practical issues such as the participant recruitment and development of metrics are discussed. The paper concludes with a critical evaluation of several usability claims made by voting machine manufacturers.

Everett, S. P., Greene, K. K., Byrne, M. D., Wallach, D. S., Derr, K., Sandler, D., & Torous, T. (2008). *Electronic voting machines versus traditional methods: Improved preference, similar performance.* Paper presented at CHI 2008, Florence, Italy.

> The usability of a computer-based direct recording electronic (DRE) voting system was compared to more traditional voting techniques including paper ballots, punch cards, and lever machines. The usability of each method was determined using efficiency, effectiveness, and user satisfaction metrics. The results indicate that there is little difference between the DRE and the traditional methods in efficiency (time to completion of ballot) and efficacy (error rate). However, the DRE was reliably superior to the traditional methods in terms of user satisfaction. These results indicate a disconnect between the subjective and objective usability of DREs.

Greene, K. K., Byrne, M. D., & Everett, S. P. (2006). *A comparison of usability between voting methods.* Paper presented at the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop, Vancouver, Canada.

> There is no baseline usability data for traditional voting methods, such as lever machines and paper ballots, to compare the new direct recording electronic (DRE) voting system to. In this study, the usability of three traditional voting methods was compared. The efficiency, effectiveness, and user satisfaction of two paper-based ballots (one open-response and one bubble ballot) and one mechanical lever machine were measured. The efficiency (time to completion of ballot) and efficacy (error rate) of the three methods did not significantly differ. However, there were significant differences in user satisfaction for the three methods.

Participants reported that they were most satisfied with the bubble ballot and least satisfied with the lever machine.

Herrnson, P. S., Niemi, R. G., Hanmer, M. J., Bederson, B. B., Conrad, F. C., & Traugott, M. W. (2006). *The importance of usability testing of voting systems.* Paper presented at the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop, Vancouver, Canada.

The usability of six voting systems was assessed by expert reviews, a laboratory test, and a field study. Across the six systems, usability problems were identified in signing-on to the machines, navigating the ballot, reviewing and changing votes, marking write-in candidates, and casting the ballot. In the field study, most voters ignored the paper trails provided by the machines. Although most voters were generally able to vote as intended both inside and outside the laboratory, certain activities proved to be problematic; these included changing votes, detecting errors, and making a straight-party vote. The types of errors that occurred most frequently differed across the voting machines, suggesting that each machine had unique deficiencies.

Herrnson, P. S., Niemi, R. G., Hanmer, M. J., Bederson, B. B., Conrad, F. C., & Traugott, M. W. (2008). *Voting technology: The not-so-simple act of casting a ballot.* Washington, DC: Brookings Institution Press.

The authors evaluated five commercially available voting systems and one prototype system. Evaluation metrics included ease of use, speed, and accuracy. Expert reviews and observations of users indicated that mechanical interfaces, such as scroll wheels and buttons, and interfaces that present the entire ballot at once pose greater physical and mental challenges.

The authors recommend that usability testing include poll worker operations, including voting machine setup, maintenance, and shut down. These tasks can be unclear and difficult, and recovery from mistakes is often complicated.

Herrnson, P. S., Bederson, B. B., Lee, B., Francia, P. L., Sherman, R. M., Conrad, F. C., . . . Niemi, R. G. (2005). Early appraisals of electronic voting. *Social Science Computer Review, 23*(3), 274-292.

In response to the problems in the 2000 U.S. elections, new electronic voting machines have become more popular because of the speed and accuracy with which they are able to record and tabulate votes. However, there is little evidence about the interface between the voter and the voting system to support this transition. Some of the concerns include: the accessibility of the system; the effects of age and technical experience on usability; the potential for bias; the costs associated with purchasing, evaluating, and maintaining new systems as well as training election workers on the new technology; and the security of electronic voting machines. The authors evaluated the Diebold AccuVote-TS machine in a series of studies involving expert review, close observation, a field test, and an exit poll. The results of the study indicated that, while the systems worked well, there were several issues related to usability and user-acceptance that need to be addressed.

Norden, L., Kimball, D., Quesenbery, W., & Chen, M. (2008). *Better ballots*. New York: New York University School of Law, The Brennan Center for Justice.

> The authors provide substantial evidence that a large number of voters have been disenfranchised by poor ballot design. They document empirical evidence from past elections to support their case. The solution, of course, is to produce ballots that are more simple and easy to use. The report outlines ballot design problems, laws that interfere with good design and usability, and policy recommendations and directions for the future. A checklist for evaluating ballot usability is also provided.

Sherman, A. T., Gangopadhya, A., Holden, S. H., Karabatis, G., Koru, A. G., Law, C. M., . . . Zhang, D. (2006). *An examination of vote verification technologies: Findings and experiences from the Maryland study.* Paper presented at the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop, Vancouver, Canada.

> A technical review of vote verification systems was conducted for the Maryland State Board of Elections. The vote verification and post-election auditing capabilities of five touchscreen vote verification machines, to be used in conjunction with a ballot machine, were evaluated. Other secondary considerations of the evaluation included general functionality, security, reliability, accessibility, and privacy. The evaluation results concluded that the currently used Diebold voting system (ballot) could provide better vote verification by being integrated with any of the four vote verification systems. Only small modifications would be needed for integration of the voting machine with the vote verification machine.

Yee, K. P. (2007). *Extending prerendered-interface voting software to support accessibility and other ballot features.* Paper presented at the 2007 USENIX/ACCURATE Electronic Voting Technology Workshop, Boston, MA.

> A pre-rendered user interface (PRUI) can be designed and audited independently of the voting machine manufacturers. This paper describes software to be used on a PRUI system in conjunction with accessible technologies, including touchscreen interfaces, alternate input devices, and concurrent speech output (i.e., synchronized audio and visual displays). A prototype was developed in Python.

Yee, K. P., Wagner, D., Hearst, M., & Bellovin, S. M. (2006). *Prerendered user interfaces for higher-assurance electronic voting.* Paper presented at the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop, Vancouver, Canada.

> The authors developed a software program, which they call a pre-rendered user interface (PRUI), but can be published before election day. The PRUI is an electronic sample ballot that could enable the general public to participate in the verification, usability testing, and accessibility testing of the ballot to be used on election day. Problems that are identified by the public could be remedied before the election. By preparing the user interface apart from the

voting machine, the difficulty of software verification is greatly reduced. The prototype developed by the authors supports a variety of user interface styles.

Security & Privacy Issues in Voting

Dawkins, S. & Gilbert, J. E. (2010). *An approach for anonymous spelling for voter write-ins using speech interaction.* Paper presented at the NAACL HLT 2010 Workshop on Speech and Language Processing for Assistive Technologies, Los Angeles, CA.

Users should be able to vote and verify their ballots in private, without assistance. It is difficult to ensure voter privacy with a voting machine that uses speech input. It is particularly difficult to enabled private write-in voting by users with upper mobility impairments. The authors describe a novel system (Prime III) to provide a solution. The system uses speech input and name prediction to allow voters to verbally yet privately spell a Reagan candidate. Voters select from numbered clusters of letters by speaking the respective numbers. Then they select a numbered letter from within that cluster. An empirical study found that the novel system was both effective and efficient.

Haas, B. (2006). *Engineering better voting systems.* Paper presented at the DocEng'06 ACM symposium on Document Engineering, Amsterdam, Netherlands.

This paper outlines some of the requirements of a voting system to guarantee trustworthy elections. These requirements include privacy, free will, reliability, prevention against ballot fraud, prevention against ballot trade, accessibility, affordability, and simplicity and usability. Because strong security often conflicts with usability, the potential for large-scale mistakes should be of greater concern than small-scale mistakes in the tradeoff between usability and security. The author also compares remote voting to poll voting and electronic ballots to paper ballots. While poll voting is more costly and complex than remote voting, it is nearly impossible to ensure the security and secrecy of ballots in remove voting. Voters generally prefer electronic ballots over paper ballots, but the potential for systematic mistakes and security breaches is greater. Given these considerations, the worst possible voting system in terms of security is internet voting and the best possible voting system includes a paper trail. Specifically, the author recommends a combination of electronic voting with a paper trail and voting by mail.

Keller, A. M., Mertz, D., Hall, J. L., & Urken, A. (2004). *Privacy issues in an electronic voting machine.* Paper presented at the 2004 ACM Workshop on Privacy in the Electronic Society, Washington, DC.

The Open Voting Consortium's electronic voting system provides voter privacy and review capability. Unlike many other Direct Recording Electronic voting machines, the Open Voting Consortium's machine uses open source software that can be inspected by the general public. The machine also improves voter privacy by implementing bar codes on printed ballots; transparency of poll worker software used to activate smart cards (which in turn are used by voters to activate voting machines); and providing private, audible readouts to blind voters.

Remote & Absentee Voting

Hoke, C. (2009). *Internet voting: Structural governance principles for election cyber security in democratic nations.* Paper presented at the Second International Symposium on Global Information Governance, Prague, Czech Republic.

> Internet voting may become more common in the near future, and associated security concerns will play a role in technology acceptance. Worldwide, governments often disregard opinions of computer security experts on the matter. The Internet provides little assurance of Data Security and integrity, and the transmission of information is susceptible to various attacks.
>
> The authors recommend that the each government appoint a policy board, whose members have the necessary technical expertise, and whose decisions are transparent to the public, to ensure end-to-end auditability of Internet voting technology. Rather than relying on a set of technical standards to be met, the policy board should assess proposals for internet voting systems on a case by case basis. Finally, democratic nations should notify each other of threats and attacks.

Krimmer, R., Triessnig, S., & Volkamer, M. (2007). *The development of remote e-voting around the world: A review of roads and directions.* Paper presented at The International Conference on E-voting and Identity, Bochum, Germany.

> Despite technological capabilities, governments have been slow to adopt remote electronic voting via the Internet. The authors surveyed 104 internet elections held worldwide. They found that documentation of security and privacy issues were scarce in these elections. Before Internet voting can become widespread, a great deal of research and documentation needs to be accomplished. Future studies should compare the effectiveness of various methods to ensure accurate voter verification, anonymity, system usability, and cost. A potential untapped data source is internet elections held in private organizations – a domain in which internet voting is much more common.

Popoveniuc, S. & Lundin, D. (2007). *A simple technique for safely using punchscan and Pret a Voter in mail-in-elections.* Paper presented at The International Conference on E-voting and Identity, Bochum, Germany.

> Traditional mail-in absentee ballots can be difficult to audit, use, and understand, and they do not ensure anonymity. This paper reviews the security of two mail-in systems –Punchscan and Pret a Voter – and discusses the novel system that overcomes their deficiencies. The proposed system employs unique serial numbers on each ballot, in combination with randomized letters associated with each choice on the ballot. Following the election, the serial number and letters from each ballot are published on the Internet. Voters can check their record against the published record to determine whether their vote was cast as intended.

Puiggali, J. & Morales-Rocha, V. (2007). *Remote voting schemes: A comparative analysis.* Paper presented at The International Conference on E-voting and Identity, Bochum, Germany.

> Remote electronic voting via fax, e-mail, and the Internet can provide greater reliability than traditional mail-in ballots, which can be lost or delayed in the mail. Key considerations for the comparative evaluation of these methods including security (e.g., privacy and auditability), usability, intellect and management (e.g., vote counting). Although the public retains a general concern that internet voting is not secure, the present heuristic evaluation concluded that the risks associated with Internet voting are not more numerous than those associated with other forms of remote electronic voting, and many safeguards can mitigate the risks.

Qadah, G. Z. & Taha, R. (2007). Electronic voting systems: Requirements, design, and implementation. *Computer Standards & Interfaces, 29,* 376-386.

> Remote electronic voting technology provides the possibility of lowering costs, increasing participation, and improving the accuracy of election results. This paper discusses design requirements and implementation of a remote electronic voting system, which enables voters to cast votes anytime and anywhere using personal computers, personal digital assistants, and cell phones. The voting system does not require the generation of content that is specific to each type of device. Instead, versatile technology such as extensible markup language can be used to represent the data content and style sheets, which can customize the ballot presentation for different connecting devices.

Reinhard, K. & Jung, W. (2007). *Compliance of POLYAS with the BSI protection profile - Basic requirements for remote electronic voting systems.* Paper presented at The International Conference on E-voting and Identity, Bochum, Germany.

> In the past year and a half a group of experts in electronic voting developed a Common Criteria Protection Profile describing basic requirements for remote electronic voting systems. This work was lead managed by the German Federal Office for Information Security (BSI) and the German Research Center for Artificial Intelligence (DFKI) and initiated by the German Gesellschaft fur Informatik (GI - society for informatics). To complete this work Micromata's POLYAS system, which is used for the GI elections needs to be evaluated against this Protection Profile. As a first step a high-level evaluation based on the security objectives has been carried out. The results are presented in this paper.

Guidelines & Best Practices in Voting

Chisnell, D., Becker, S., Laskowski, S., & Lowry, S. (2009). *Style guide for voting system documentation: Why user-centered documentation matters to voting security.* Paper presented at EVT/WOTE'09: The 2009 conference on electronic voting technology/workshop on trustworthy elections, Montreal, Canada.

> Unlike most research papers that focus on the usability for voters, this paper discusses the effects of usability for poll workers on the security of the voting process. In their study focusing

on voting system documentation for poll workers, the authors discovered usability issues that could potentially lead to security issues. Based on their research, the authors suggest eight categories of guidelines for developing voting system documentation.

Election Assistance Commission (2005). Election Assistance Commission Guidelines. Retrieved from http://www.eac.gov/testing_and_certification/voluntary_voting_system_guidelines.aspx.

The Voluntary Voting System Guidelines (VVSG) is a set of specifications and requirements developed in accordance with the Help America Vote Act (HAVA) for testing the functionality, accessibility, and security of voting systems. The guidelines, adopted in 2005, update the Voting System Standards. Version 1.1 of the guidelines is a proposed revision to the VVSG that has not been officially adopted.

Election Assistance Commission (2007). Effective Designs for the Administration of Federal Elections.

This document discusses the importance of effective information design in creating election materials that are usable, clear, and accurate. The information design of ballots (both optical scan and touchscreen), sample ballots, announcements, instructions, and voting rights are considered. The design suggestions are informed by legislation, design principles, and research conducted involving voters, subject matter experts, election officials, poll workers, and voting equipment providers. Additionally, this report contains the results of a user-centered research process involving ten research events including pilot testing in Nebraska.

Human Factors and Privacy Subcommittee of the Technical Guidelines Development Committee (TGDC). *Usability performance benchmarks for the Voluntary Voting System Guidelines.* Retrieved November 8, 2011, from http://vote.nist.gov/meeting-08172007/Usability-Benchmarks-081707.pdf.

This report describes the requirements for the Voluntary Voting System Guidelines (VVSG) and the standard method for testing the usability of voting systems. Additionally, the report describes how the metrics and benchmarks were developed. The performance benchmarks were based on usability data collected on a variety of voting systems include direct recording electronic systems, electronic ballot markers, and precinct count optical scanners. Voting systems that meet or exceed the benchmarks are considered to have good usability. Voters using these systems should be able to cast their votes more accurately and with less confusion.

Laskowski, S. L., & Redish, J. (2006). *Making ballot language understandable to voters.* Paper presented at the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop, Vancouver, Canada.

History has shown that simple matters such as the wording and placement of instructions can significantly affect voters' ability to cast their votes as intended. Although an extensive study of these factors in the voting domain has not been conducted, best practices have been developed from research in other domains. These best practices include but are not limited to the following: state consequences before users are likely to act, state context (consequence) before action, avoid the use of technical language, state instructions and logical order.

Redish, J. & Laskowski, S. J. (2009). *Guidelines for writing clear instructions and messages for voters and poll workers* (NISTIR 7596). Gaithersburg, MD: National Institute of Standards and Technology.

This document provides 20 guidelines for developing clear ballot instructions, both electronically and paper-based. Guidelines are divided into five categories: placement, order, sentences, words, and topics. Both good and bad examples are provided for each guideline. The document also provides guidelines for system messages on direct recording electronic voting machines such as error messages.

Stone, M., Laskowski, S. J., & Lowry, S. Z. (2008). *Guidelines for using color in voting systems* (NISTIR 7537). Gaithersburg, MD: National Institute of Standards and Technology.

This document provides guidelines for the use of color in electronic voting systems. The guidelines are intended to promote usability, such as legibility, as well as accommodate users with visual impairments, such as color vision deficiencies and low vision.

United States Department of Justice (2004). *ADA checklist for Polling Places.* Washington, DC: Author.

This document provides a checklist for evaluating the physical accessibility of polling places for individuals with mobility and visual impairments. Included are barriers to getting to the polling place, entering the polling place, and using the polling place (i.e., the voting area). It does not address the accessibility of the voting machine interface.

Voting Systems Standards, 42 U.S.C. § 15481.

These standards provide requirements for voting systems used in an election for Federal office. Included are requirements relating to the accessibility of the voting system for individuals with disabilities. Specifically, the statute states that the voting system must be accessible for blind and visually impaired individuals, and at least one direct recording electronic voting system must be available at each polling place.

Weldemariam, K., Mattioli, A., & Villafiorita, A. (2009). Managing requirements for e-voting systems: Issues and approaches motivated by a case study. Paper presented at RE-Vote09 First International Workshop on Requirements Engineering for e-voting Systems, Atlanta, GA.

From a technical perspective, the authors describe their experiences and recommendations for the process of following laws and standards for the development and management of electronic voting systems. The relationship between system architecture and system requirements is based on finite state voting machines that determine actual behavior of the voting machine.

Voting Device Assessment Methods

Quesenbery, W. (2004). *Defining a summative usability test for voting systems.* A report from the UPA 2004 Workshop on Voting and Usability, Minneapolis, Minnesota.

This paper describes the work conducted by a group at the 2004 Usability Professionals' Association annual conference in "creating a fully-defined usability test protocol for a voting system standard." Building on the work of John O'Hara's 2003 white paper, "A Proposed Approach to Testing the IEEE Usability/Accessibility Standards", this paper attempts to describe identify and describe metrics for establishing pass/fail criteria for a conformance test.

Selker, T., Rosenzweig, E., & Pandolfo, A. (2006). A methodology for testing voting systems. *Journal of Usability Studies, 2*(1), 7-21.

This paper describes the importance of testing voting technology in realistic settings rather than lab style experiments. Testing in realistic settings exposes the challenges in voting process control as well as maintaining consistent voting experiences. For example, the authors discovered that poll workers and polling place conditions affect the usability of the voting process as much as voting machines. The paper concludes with a recommended protocol for testing voting technology in realistic settings.

Traugott, M. W. (2002). *Testing alternative hardware and ballot forms.* Paper presented at the meeting of the Working Group on Voting Technologies and balloting, held at the University of Maryland, College Park, MD.

This paper reviews methods for evaluating alternative hardware and ballot designs. The proposed methods include a series of basic research studies complemented with focus groups and an applied research study involving the development of a facility designed to mimic "real world" conditions. The author raises issues with each of the methods in terms of feasibility and cost.

Usability Professionals' Association. (2007). LEO Kit: Usability Testing for Local Election Officials. Retrieved from http://www.upassoc.org/civiclife/voting/leo_testing.html.

The goal of this project was to create a testing kit that would allow individuals with no training in usability or human factors engineering to test the usability of ballots before an election. The kits are specifically designed to be used by local election officials (LEOs), hence the term the LEO kit. Available on the website for the Usability Professionals' Association, the LEO kits consists of an instructional guide, a session script, session materials (i.e., forms for participants), a sample test report, and training workshop handouts.

User-Centered Design, Inc. (2006). Preliminary report on the development of a user-based conformance test for the usability of voting equipment.

This paper describes conformance tests for the usability of voting systems based on human performance testing. The tests are designed to determine whether a system meets performance requirements using potential voters as participants. As a conformance test, the system may either pass the test if it meets the requirements or fail if any requirements are not met. The

conformance tests do not involve individuals with disabilities. The authors suggest the development of another test method for users with disabilities.

Traumatic Brain Injuries

Brahm, K. D., Wilgenburg, H. M., Kirby, J., Ingalla, S., Chang, C., & Goodrich, G. L. (2009). Visual impairment and dysfunction in combat-injured service members with traumatic brain injury. *Optometry and Vision Science, 86,*(7), 817-825.

This study determined the frequencies of visual impairments among military personnel who had been treated at the the Polytrauma Network Site (PNS, outpatient facility) and the Polytrauma Rehabilitation Center (PRC, inpatient facility). A vision screening assessment of showed that 90% of PNS-outpatients and 84% of PRC-inpatients had TBIs associated with a blast event. Visual dysfunctions, including lens accommodation and oculomotor problems, were common in both populations. Poor visual acuity (20/100 or worse) was much less common. The findings suggest that military personnel who suffer from blast-induced TBI are at risk for visual dysfunction; in particular, they may often face difficulties with changing focal distance (i.e., accommodation) and with eye movements (i.e., convergence, smooth pursuit, and saccades).

Cifu, D. X., Cohen, S. I. Lew, H. L., Jaffee, M., & Sigford, B. (2010). The history and evolution of traumatic brain injury rehabilitation in military service members and veterans. *American Journal of Physical Medicine & Rehabilitation, 89,*(8), 688-694.

The incidence of TBI has recently increased, perhaps due to changes in weaponry and increase survival rates. This paper gives a historical account of the medical community's adaptation to combat-related injuries over the years. The Department of Veterans Affairs and the Defense and Veterans Brain Injury Center have made a great impact how soldiers with traumatic brain injury are evaluated and treated. Several facilities and many clinical teams have recently been created to specifically focus on treating soldiers with polytrauma and traumatic brain injury.

Cockerham, G. C., Goodrich, G. L., Weichel, E. D., Orcutt, J. C., Rizzo, J. F., Bower, K. S., & Schuchard, R. A. (2009). Eye and visual function in traumatic brain injury. *Journal of Rehabilitation Research & Development, 46*(6), 811-818.

Traumatic brain injury in the civilian sector is often associated with visual dysfunctions, which include difficulty changing focal distance and moving the eyes. Often, no reduction in visual acuity occurs. Civilian TBI is often caused by blunt force trauma (e.g., automobile accidents) whereas combat-related TBI is often caused by blasts. Relative to the civilian sector, little is known about the visual effects of military (blast-induced) TBI. Blasts sometimes directly cause eye injury, which can be quickly detected and treated. When the eyes are not directly damaged, the treatment of visual dysfunctions caused by TBI might often be delayed. To rectify this, the authors suggest many lines of the research that should be pursued, such as the development of assessment tools, comparison of treatment methods (e.g., surgical interventions and

pharmacological therapies), and a systematized method of documenting the success of rehabilitation.

Colantonio, A., Ratcliff, G., Chase, S., Kelsey, S., Escobar, M., & Vernich, L. (2004). Long term outcomes after moderate to severe traumatic brain injury. *Disability and Rehabilitation, 26*(5), 253-261.

This study addressed long-term quality of life issues (e.g., self-rated health, employment, and activity limitations) for veterans who had suffered TBI at least 15 years prior to the study. The greatest challenges faced by respondents (N = 306) were related to driving, shopping, and managing finances. Many veterans with TBI may need long term assistance with these activities of daily living despite rehabilitation efforts.

Davis, C., Nelson, J., Hirsch, M. A., Hammond, F. M., Karlawish, J., Schur, L, Kruse, D., & Ball, A. (2010). An exploratory examination of political empowerment and voting among individuals with TBI. *Brain Injury, 24*(3), 208.

This study used a community-based participatory research approach to assess the voting experience of individuals with TBI (along with their caregivers and family members) during the November 2007 and May 2007 General Election and the November 2008 Presidential Election in North Carolina. Interviews were conducted with 55 individuals with TBI, and with 27 spouses, caregivers, and healthcare and community providers of people with TBI. Participants were shadowed and observed as they voted at the polls. The study found that people with TBI can require extra resources (time, effort, transportation) to vote, and that people with TBI have challenges with remembering to vote, preparing to vote, researching candidates, and arranging transportation to the polls. Some people with TBI also note challenges navigating the polls and the ballot, and difficulty remembering who to vote for.

Doarn, C. R., McVeigh, F., & Poropatich, R. (2010). Innovative new technologies to identify and treat traumatic brain injuries: Crossover technologies and approaches between military and civilian applications. *Telemedicine and e-Health, 16*(3), 373-381.

The ubiquitous use of improvised explosive devices in Iraq and Afghanistan has contributed to the recent increase of TBI seen in the military. Higher rates of survival are also responsible. Although there has been a reduction in severe TBI, perhaps due to improved armor, mild and moderate TBI have increased. Because the physical and mental effects of TBI are often misdiagnosed, the U.S. Army is pursuing methods for early TBI detection and treatment. To pursue this subjective, the U.S. Army's Telemedicine and Advanced Technology Research Center collaborated with a civilian organization –the American Telemedicine Association – to hold a research symposium on the diagnosis and treatment of TBI. This paper documents the session topics at the symposium and gives general summaries of some of the presentations. This may be a good resource for finding current researchers in the field.

Doarn, C. R. (2009). Symposium report: Innovative new technologies to identify and treat traumatic brain injuries: Crossover technologies and approaches between military and civilian applications, Indian Wells, CA.

These symposium presentations are focused on current activities in diagnosis and treatment of TBI using various technologies from subject matter experts. One focus of discussion is the use of telemedicine in the diagnosis and treatment of TBI. The use of tele-rehabilitation for TBI patients is also discussed.

Dobscha, S. K., Clark, M. E., Morasco, B. J., Freeman, M., Campbell, R., & Helfand, M. (2009). Systematic review of the literature on pain in patients with poly-trauma including traumatic brain injury. *Pain Medicine, 10*(7), 1200-1217.

This literature review addressed pain assessment and management in patients with polytraumatic injuries, including blast-related headache and TBI. It covered studies published from 1950 to 2008. Most studies found in the literature search did not include a control group, but instead included observational and qualitative studies. The search criteria yielded one review paper, 93 observational studies, and one qualitative study. Surprisingly, the search did not yield any studies that evaluated the quality of pain-intensity measures or pain-related functional limitations among patients with TBI. There were also no studies that compared blast-related headache with other types of headache, or that evaluated treatment options for blast-related chronic headaches. Symptoms associated with TBI varied widely across studies; variables included pain severity and location, insomnia, fatigue, post-traumatic stress disorder, and depression. The authors advocated further research to guide pain assessment and management for individuals suffering from polytrauma.

DuBose, J. J., Barmparas, G., Inaba, K., Stein, D. M., Scalea, T., Cancio, L. C., Cole, J., Eastridge, B., Blackbourne, L. (2011). Isolated severe traumatic brain injuries sustained during combat operations: Demographics, mortality outcomes, and lessons to be learned from contrasts to civilian counterparts. *Journal of Trauma, 70,*(1), 11-18.

The epidemiology of severe TBI from the civilian and military (Joint Trauma Theatre Registry) sectors was compared. Patient demographics, treatments, and outcomes were reviewed. Military personnel were significantly more likely than their civilian counterparts to receive intracranial pressure monitoring and neurosurgery. Mortality was lower among military personnel overall, especially in cases of penetrating brain injury. It is suggested that the pressure monitoring and surgical interventions received by military personnel are partially responsible for their higher rates of survival. However, many other factors might play a role.

French, L. M., & Parkinson, G. W. (2008). Assessing and treating veterans with traumatic brain injury. *Journal of Clinical Psychology: In Session, 64*(8), 1004-1013.

This article discusses comorbid injuries and the environmental context in which TBI is sustained by military personnel in recent conflicts. Comorbid injuries in the environmental stressors

greatly complicate clinical approaches. The influences of these factors are illustrated with case vignettes.

Hoge, C. W., McGurk, D., Thomas, J. L., Cox, A. L., Engel, C. C., & Castro, C. A. (2008). Mild traumatic brain injury in U.S. soldiers returning from Iraq. *New England Journal of Medicine, 358*(5), 453-463.

The authors surveyed 2525 U.S. Army infantry soldiers 3 to 4 months after their return from deployment. The purpose of the survey was to determine rates of TBI comorbidity with PTSD and major depression, and their combined effects on physical health. The survey consisted of validated measures of TBI, depression, and PTSD. Questions also addressed physical health. Fifteen percent of respondents reported symptoms that were indicative of mild TBI.

Of those who reported loss of consciousness, 43.9% reported symptoms indicative of PTSD. Among other groups who did not report a loss of consciousness, PTSD symptoms were reported much less frequently. Those with mild TBI, particularly those who had lost consciousness, were significantly more likely to report poor health outcomes. However, after a statistical adjustment for PTSD and depression, mild TBI was not significantly associated with physical health outcomes. The results suggest that the relationship between mild TBI and physical health problems is mediated by depression and PTSD; that is, those individuals who suffer from TBI but not depression or PTSD are less likely to suffer from physical health problems.

Iverson, G. I. (2010). Clinical and methodological challenges with assessing mild traumatic brain injury in the military. *Journal of head Trauma Rehabilitation, 25*(5), 313-319.

This article reviews a screening program designed to detect residual symptoms of mild TBI. The authors provide a critical review the current screening program, discuss its challenges, and make recommendations for its improvement. One problem with the current screening program is its inability to determine when a TBI may have been sustained for individuals who have served multiple tours of duty. Another limitation is that TBI may be sufficient but not necessary to generate some of the symptoms that are targeted by screening questions. Most critically, this screening program has a limited ability to dissociate TBI from PTSD and depression. Careful documentation and further research are needed to improve the program.

Lew, H. L., Garvert, D. W., Pogoda, T. K., Hsu, P. T., Devine, J. M., White, D. K., . . . Goodrich, G. L. (2009). Auditory and visual impairments in patients with blast-related traumatic brain injury: Effect of dual sensory impairment on Functional Independence Measure. *Journal of Rehabilitation Research & Development, 46*(6), 819-826.

In this study of 175 patients with blast-related traumatic brain injury (TBI), it was found that 19%, 34%, and 32% of the patients showed clinical signs of hearing impairment, vision impairment, and dual sensory impairment (hearing and vision), respectively. A measure of functional independence was also administered; it comprised a motor subscale and a cognitive subscale. Statistical analysis showed a sensory-group difference for the motor functional independence scores at the time at discharge from a clinical care facility. Regarding improvement over time, the dual sensory impairment group showed significantly less improvement in motor functional independence.

Lew, H. L., Weihing, J., Myers, P. J., Pogoda, T. K., & Goodrich, G. L. (2010). Dual sensory impairment (DSI) in traumatic brain injury (TBI): An emerging interdisciplinary challenge. *NeuroRehabilitation, 26*, 213-222.

Dual sensory impairment (DSI), which often accompanies TBI, is marked by auditory and visual deficits that are either peripherally or centrally based. This review covers unimodal deficits as well as DSI in the military population. The heterogeneous nature of TBI injuries creates a challenge for clinicians to dissociate, for diagnostic and rehabilitative efforts, the effects of multiple sensory deficits from cognitive deficits. Current treatments for DSI include training exercises and sensory aids.

McCarthy, M. L., Dikmen, S. S., Langlois, J. A., Selassie, A. W., Gu, J. K., & Horner, M. D. (2006). Self-reported psychosocial health among adults with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 87,* 953-961.

Symptoms associated with TBI are not limited to cognitive deficits, but also include physical and psychosocial problems, such as depression, anxiety, and social withdrawal. This study reports subjective measures of psychosocial health of 7612 civilians one year after their discharge from clinics. Twenty-nine percent reported poor psychosocial health. The following factors were positively associated with poor psychosocial health: female sex, younger age, Medicaid coverage, lack of health insurance, poor social support, cognitive deficits, and substance abuse. Of those who reported poor psychosocial health, only 36% reported receiving mental health care. To improve TBI rehabilitation, clinicians should attend to patients' psychosocial health needs in the period following acute treatment.

Mount Sinai Medical Center (2008). What Impact Will Moderate or Severe TBI Have on a Person's Life? Retrieved from http://www.brainline.org/content/2008/07/what-impact-will-moderate-or-severe-tbi-have-persons-life.html.

This article discusses the long-term functional deficits of TBI. A wide variety of bodily functions controlled by the brain may be affected. Given the fact that TBI produces heterogeneous symptoms, individuals may experience only one, several, or most of the possible effects. Furthermore, rehabilitative improvements (or lack thereof) vary greatly across individuals. Moderate-to-severe TBI often causes deficits in basic cognitive skills, such as the ability to sustain attention, remember newly learned material, think creatively, adapt to changes in routine, and make decisions based on many constraints. Personality traits, such as neuroticism, motivation, and social inhibition may also be altered. The social problems are compounded when patients deny (or are unaware of) the effects of their injuries. This denial can also impede rehabilitation. Other problems include sensory deficits, paralysis, chronic pain, and hormonal imbalances. Given the diversity of symptoms, it follows that the success of rehabilitation varies greatly among individuals. Some individuals will completely recover after several years, whereas others will improve but never fully recover.

Pagulayan, K. F., Hoffman, J. M., Temkin, N. R., Machamer, J. E., & Dikmen, S. S. (2008). Functional limitations and depression after traumatic brain injury: Examination of the temporal relationship. *Archives of Physical Medicine and Rehabilitation, 89,* 1887-1892.

A longitudinal study was conducted to determine the temporal relationship between functional limitations and depression caused by TBI. Functional limitations were measured by the Sickness Impact Profile (SIP), which assesses quality of life issues and functional abilities such as sleep and rest, body care, home management, and social relationships. Evaluations were taken at three time points. Results showed that depressive symptoms were more highly correlated with high SIP scores at later time points than earlier time points. Statistical analyses showed that increased SIP scores usually preceded increased depression, which may imply a causal effect. That is, quality of life issues and functional abilities may influence emotional well-being, but depression may not strongly affect the perception of quality of life and functional abilities. The results have implications for the treatment of TBI related depression.

Schneiderman, A. I., Braver, E. R., Kang, H. K. (2008). Understanding sequelae of injury during the conflicts in Iraq and Afghanistan: persistent postconcussive symptoms and Posttraumatic stress disorder. *American Journal of Epidemiology, 167*(12), 1446-1452.

Associations among PTSD and post-concussive symptoms of TBI were investigated by a survey. Immediate neurologic symptoms that were reported after injuries were used to identify mild TBI. About 12% of 2,235 respondents reported symptoms that were indicative of mild TBI, and 11% reported symptoms consistent with PTSD. Other than TBI, PTSD was the strongest factor associated with post-concussive symptoms.

Silver, J. M., McAllister, T. W., & Arciniegas, D. B. (2009). Depression and cognitive complaints following mild traumatic brain injury. *American Journal of Psychiatry, 166*(6), 653-661.

Problems with cognition, emotion, and behavior often accompany TBI. Although many patients improve significantly during the first several months after sustaining mild TBI, many other patients develop long-term functional problems. Some of the most common symptoms are cognitive impairment and depression. The symptoms sometimes are responsive to a combination of pharmacologic and rehabilitative treatments. This paper offers recommendations for clinical diagnosis and treatment of individuals suffering from depression and cognitive deficits following TBI.

Spencer, R. J., Drag, L. L., Walker, S. J., & Bieliauskas, L. A. (2010). Self-reported cognitive symptoms following mild traumatic brain injury are poorly associated with neuropsychological performance in OIF/OEF veterans. *Journal of Rehabilitation Research & Development, 47*(6), 521-530.

Screening for TBI is often accomplished by self-report measures, yet the accuracy of such measures is questionable. Self-report in general can be unreliable, and they may be particularly unreliable in this population who are often unaware (or in denial) of their symptoms. The study compared objective clinical assessments with self-reports in 105 service members who recently sustained mild TBI. Self-report measures of cognitive functioning were not significantly correlated with objective clinical measures. Clinicians who were surveyed tended to overestimate the association between clinical measures and self-report measures.

Taber, K. H., Warden, D. L., & Hurley, R. A. (2006). Blast-related traumatic brain injury: What is known? *The Journal of Neuropsychiatry and Clinical Neurosciences, 18*(2), 141-145.

Causes of TBI can be placed in the following three categories: blast wave-induced changes in atmospheric pressure, impact of objects that are thrown by the blast, and impact of people as they are thrown by the blast. This paper discusses the medical complications associated with each of these types of TBI.

Temkin, N. R., Corrigan, J. D., Dikmen, S. S., & Machamer, J. (2009). Social functioning after traumatic brain injury. *Journal of Head Trauma Rehabilitation, 24*(6), 460-467.

A review of published literature was conducted to determine the relationship between TBI and various social functions, including employment, relationships, functional independence, and recreation. Results indicated that unemployment was associated with moderate and severe TBI but not mild TBI. Recreation, quality of social relationships, and functional independence were also adversely affected by TBI, regardless of severity. However, injury severity did affect the severity of social problems.

Tun, C., Hogan, A., & Fitzharris, K. (2009). Hearing and vestibular dysfunction caused by blast injuries and traumatic brain injuries. *The Hearing Journal, 62*(11), 24-26.

Blasts that induce TBI often also induce damage to the auditory and vestibular systems. This paper describes the symptoms associated with damage to the auditory and vestibular systems, as well as the frequency of these injuries at the Boston VA medical clinic.

Wounded Warrier injury fact sheet on traumatic brain injury (TBI). Retrieved from http://wtc.army.mil/aw2/index.html.

The Wounded Warrior website has some informative fact sheets on some of the injuries and disabilities that occur in combat. This fact sheet on TBI includes data on prevalence, as well as information about treatment and recovery.

Other Injuries & Disabilities

Aiken, L. J., Bibeau, P., Cilento, B., & Lopez, E. (2008). Stateside care of marines and Sailors injured in Iraq at the National Naval Medical Center in Bethesda, Maryland. *Critical Care Nursing Clinics of North America, 20,* 31-40.

This paper describes the types of injuries that are most frequently seen in marines and sailors serving in Iraq and Afghanistan. Head injuries, TBI, and blast injuries are the most prevalent. Recently wounded warriors who are being treated in intensive care units (ICU)for TBI and other injuries often experience confusion and disorientation. This paper describes several case studies of ICU care at the National Naval Medical Center.

Bellamy, R. F. (2000). Combat trauma overview. In R. Zajtchuk & C. M. Grand (Eds.), *Anesthesia and perioperative care of the combat casualty*, (1-42). Washington, D. C.: Department of the Army.

It is critical for military anesthesiologists understand the unique challenges that they will face in the field – challenges that are quite different from those present in the civilian domain. This paper provides a broad but thorough historical overview of the types of injuries and methods of treatment that have occurred in recent U.S. military conflicts. Special attention is given to the environments in which injuries occur, the effects of the environment on patient prognosis, and the typical outcomes of various injuries.

Champion, H. R., Bellamy, R. F., Roberts, P., & Leppaniemi, A. (2003). A profile of combat injury. *The Journal of Trauma, 54*, S13-S19.

The causes and contexts of injuries in civilian and military sectors differ greatly; combat-related injuries bear unique considerations with regard to treatment. These include the following: the high energy of the wounding objects, multiple causes of injury, high frequency of penetrating wounds, the persistence of threat during immediate treatment in tactical settings, the resource-constrained environment, and delayed access to recommended treatments. Recognition of these factors may improve research on medical care in combat settings, and may enable better civilian-military collaboration in research.

Clark, M. E., Bair, M. J., Buckenmaier, C. C., Gironda, R. J., & Walker, R. L. (2007). Pain and combat injuries in soldiers returning from Operations Enduring Freedom and Iraqi Freedom: Implications for research and practice. *Journal of Rehabilitation Research & Development, 44*(2), 179-194.

The rate of blast-related injuries has been increasing in recent military conflicts. Military personnel suffering from blast injuries typically require significant pain management. Although clinical practices and the management of pain have been progressing, there has been a lack of associated research. Little is known about the long term pain management needs individuals who suffer from blast-related injuries. This paper reviews the current methods for pain management, acute stabilization, transport, surgical treatment, and rehabilitation.

Clark, M. E., Walker, R. L., Gironda, R. J., & Scholten, J. D. (2009). Comparison of pain and emotional symptoms in soldiers with poly-trauma : Unique aspects of blast exposure. *Pain Medicine, 10*(3), 447-455.

A retrospective review of medical records was conducted to determine whether soldiers with blast-related polytrauma presented physical and emotional signs and pain-treatment outcomes that were distinct from those of soldiers who were injured by other means. Soldiers who were injured by blasts showed a wider variety of physical injuries, higher levels of opioid analgesic use, less reduction in pain intensity after treatment, and higher rates of psychiatric disorders than those injured by other means. Blast injury may be associated with a large number of comorbid symptoms that pose greater challenges than other injuries for successful treatment.

DoD Military injury metrics working group white paper (2002).

The Military Injury Metrics Working Group was assigned the task of identifying appropriate and standardized injury metrics for the Department of Defense. This paper documents those metrics, the best sources of information regarding the metrics, and identifies limitations and consequent recommendations for improving the metrics. The group recommends four new metrics and provides suggestions for the collection of data regarding injuries. The metrics can be used to track the progress of injury prevention and treatment programs.

Galarneau, M. R., Hancock, W. C., Konoske, P., Melcer, T., Vickers, R. R., Walker, J., & Zouris, J. M. (2006). The Navy-Marine Corps Combat Trauma Registry. *Military Medicine, 171*, 691-697.

This paper describes the development of the Combat Trauma Registry (CTR) and presents studies and analyses of combat injury patterns and casualty management in the medical evacuation chain in Iraq. The CTR is a database for records of combat injuries that describe the mechanisms of injury, use of personal protective equipment, casualty demographics, levels of care that were provided, and other details associated with injuries.

Holcomb, J. B., Stansbury, L. G., Champion, H. R., Wade, C., & Bellamy, R. F. (2006). Understanding combat casualty care statistics. *Journal of Trauma, 60*, 397-401.

Treatment strategies can rapidly be adjusted in response to hospital records, but the records must be maintained well. The raw data must also be interpreted to form actionable conclusions. This requires clear and consistent terminology. The authors developed a terminology that they hoped would produce the best insight into the effectiveness of clinical care at different stages of treatment. The terminology can be applied the analysis of injury data from the Joint Theater Trauma Registry (JTTR) to determine whether treatment methods are improving.

Lew, H. J., Poole, J. H., Vanderploeg, R. D., Goodrich, G. L., Dekelboum, S., Guillory, S. B., . . . Cifu, D. X. (2007). Program development and defining characteristics of returning military in a VA Polytrauma Network Site. *Journal of Rehabilitation Research & Development, 44*(7), 1027-1034.

The Polytrauma Network Site (PNS) clinic is a critical component of the Department of Veterans Affairs (VA) Polytrauma System of Care. The PNS serves military personnel who are returning to the U.S. from combat. Injured military personnel in the current conflicts show a high prevalence of post-concussion symptoms, PTDS, cognitive deficits, back pain, headaches, visual and auditory disabilities, and problems with the vestibular system. An anonymous patient feedback survey has been used to critique and improve the clinical process.

Knapik, J. J., Canham-Chervak, M., Hauret, K., Laurin, M. L., Hoedebecke, E., Craig, S., & Montain, S. J. (2002). Seasonal variations in injury rates during US Army Basic Combat Training. *Annals of Occupational Hygiene, 46*(1), 15-23.

A review of previous literature suggested that injuries sustained during physical activity may be higher in the summer months than in the fall and winter months, perhaps due to the fact that people are more physically active in the summer. To examine this possibility, this study reviewed seasonal differences in injury rates during US Army Basic Combat Training, where physical activity was similar throughout the year. Injury data were obtained from a retrospective review of the medical records. For men, the risk of incurring an injury in the summer was significantly greater than the risk during the fall months. There was a high correlation between maximum daily temperatures and injury rates. Thus, environmental factors may contribute to the higher rate of injuries during the summer.

Masini, B. D., Waterman, S. M., Wenke, J. C., Owens, B. D., Hsu, J. R., & Ficke, J. R. (2009). Resource utilization and disability outcome assessment of combat casualties from Operation Iraqi Freedom and Operation Enduring Freedom. *Journal of Orthopedic Trauma, 23*(4), 261-266.

This study focused on the costs associated with disabilities resulting from the wars in Iraq and Afghanistan, and also provided a few ideas for obtaining data on injury and disability rates. These sources include the Joint Theater Trauma Registry (JTTS), The Department of Defense Medical Metrics (M2) database, and the US Army Physical Disability Administration database.

Pollack, P., & Rogers, C. (2007). A brief background of combat injuries. Retrieved from http://www.aaos.org/news/bulletin/marapr07/research2.asp.

Wounds that are caused by blasts and high velocity projectiles are much more common in military than civilian settings. Thus, the ability to generalize lessons learned from the treatment of civilian injuries to the treatment of military injuries is somewhat limited. This report describes some of the current trends in military injury statistics and associated challenges.

World Health Organization. (2002). *Towards a common language for functioning, disability, and health: ICF.* Geneva: Author.

The International Classification of Functioning, Disability, and Health (ICF) provides a standard language for the description and classification of health-related states. It is a classification of health-related factors that can be used to describe changes in body function and structure, as well as the physical capacities associated with each health condition. These factors are classified from several perspectives, including body, individual, and societal, by means of two lists: a list of body functions and structure, and a list of activities. The term “disability” is an umbrella term that includes functional impairments and activity restrictions. The classification scheme also lists environmental factors that may interact with these factors.

World Health Organization. (2008). *Training manual on disability statistics.* Bangkok: United Nations.

This manual asserts that accurate disability statistics are very important for the ability to determine the needs of specific individuals, because although two individuals may share the same impairment, they may face different types of difficulties in their daily lives. Therefore, information about an individual's functional status is crucial for determining their social needs and assistive technology needs. This manual is based on initiatives to improve disability statistics and measurement by promoting a common definition and methodology that is based on the International Classification of Functioning, Disability and Health (ICF). It is intended to enhance the reader's understanding of the ICF-based approach to disability measurement. It provides guidance for understanding how to collect data regarding disabilities. It also covers data structuring, analysis, and dissemination.

Zouris, J. M., Walker, G. J., Dye, J., Galarneau, M. (2006). Wounding patterns for U.S. Marines and sailors during Operation Iraqi Freedom, major combat phase. *Military Medicine, 171*, 246-252.

This study examined the injuries sustained by 279 military personnel who had been wounded in Iraq. The goal was to determine the patterns of injuries that were caused by various wounding agents. On average, personnel were diagnosed with 2.2 injuries. Open wounds and fractures were the most common types of injury. Small arms and explosive munitions accounted for approximately 75% of the injuries. Upper and lower extremity wounds accounted for about 70% of all injuries. This percentage is consistent with those seen in military conflict since World War II, although the anatomical distribution has changed due to advances in personal protective equipment.

Systems & Policies Related to Disabilities

Disability counseling guide for PEB liaison officers.

This guide provides assistance in processing disability cases as well as counseling military members for the Physical Evaluation Board Liaison Officer (PEBLO). The document outlines the steps involved in Medical Evaluation Board (MEB) processing and describes the disability evaluation system, including the Informal and Formal Physical Evaluation Boards as well as the different possible outcomes (e.g., return to duty, disability retirement, or temporary retirement).

Disability Evaluation System (chapter 2 of the Handbook for Injured Service Members and Their Families).

Chapter 2 discusses the Disability Evaluation System (DES). The DES was created “to provide a uniform procedure for the evaluation of a service member's medical condition and the member's ability to continue his or her military service”. The DES consists of two stages. The first stage is the Medical Evaluation Board (MEB) phase in which the service member's injury and treatment are evaluated to determine if he or she can continue serving after treatment. The second stage is the Physical Evaluation Board (PEB) in which the service member's physical

ability to serve in the military is determined. At this point, the service member is assigned a disability rating if he or she is unable to continue serving.

Disability Rating System (chapter 3 of the Handbook for Injured Service Members and Their Families).

Chapter 3 discusses the Veterans Administration Schedule for Rating Disabilities (VASRD) and its use by the military and the Department of Veteran Affairs (VA). When a service member is deemed unfit for military duty and is separated from the military, the military disability rating determines if the service member is eligible for Department of Defense (DoD) disability retirement pay, or if the service member will instead receive severance pay. Service members must have an aggregate disability rating of at least 30% to qualify for the DoD retirement pay. Even if the service member does not qualify for the DoD retirement pay, he or she may still be eligible for disability benefits from the Department of Veteran Affairs (VA). The VA also assigns a different disability rating that may be higher than the military disability rating because the VA considers all of the individual's medical conditions. Although the disability ratings may differ between the military and the VA, both use the VASRD.

Marcum, C. Y., Emmerichs, R. M., Sloan, J. S., & Thie, H. J. (2002). Disability Evaluation System Overview. In Methods and Actions for Improving Performance of the Department of Defense Disability Evaluation System (pp.13-42). Santa Monica, CA:RAND.

Chapter 3 provides an overview of the DoD Disability Evaluation System from five perspectives. These perspectives include its purpose and desired outcomes, its customers, its organizational settings, the operating framework that is common to all military departments, and the aspects that are unique to each military department.

Oliver, C. (n.d.). Physical evaluation board process.

This presentation reviews the Physical Disability Evaluation System (PDES) and illustrates the disability case flow.

Rating Process and System (chapter 4 of Honoring the Call to Duty: Veterans' Disability Benefits in the 21st Century).

Chapter 4 describes the Department of Veterans Affairs (VA) Schedule for Rating Disabilities. The Rating Schedule is used to determine the severity of disability and, in turn, the amount of monthly composition. This chapter reviews the current system and provides many recommendations for improving the system.

U.S. Marine Corps Wounded Warrior Regiment (n.d.). Disability Evaluation System (Pilot): Pocket Guide for Marines.

This guide reviews the Disability Evaluation System (DES) for Marines and their families. The guide includes information on the Medical Evaluation Board, the Physical Evaluation Board, the transition phase, and the VA disability compensation delivery phase. Included is a DES Pilot

Process Chart showing the process and decision points involved in the DES from medical treatment to the finalization of the case.

Appendix B: Structured Interview Battery

Background Information:

[To be completed prior to conducting the interview based on the subject population requested and site visited. Do not request access to patient medical records. All data is to remain anonymous (i.e., de-identified) in order to preserve patient confidentiality.]

Military Status: Active Duty Transitional Veteran

Level of Care: Inpatient Outpatient Transitional

Level of rehabilitation (if applicable):

TBI: Acute Sub-Acute Transitional

Polytrauma: Rehab Center Network Site Support Team POC Transitional

Instructions to Participant:

This interview is about difficulties people have because of health conditions. By health condition I mean diseases or illnesses, other health problems that may be short or long lasting, and injuries, mental or emotional problems.

I will remind you to keep all of your health problems in mind as you answer the questions. When I ask you about difficulties in doing an activity think about: increased effort, discomfort or pain, slowness, or changes in the way you do the activity.

When answering, I would like you to think back over the last 30 days. I also would like you to answer these questions thinking about how much difficulty you have, on average over the past 30 days, while doing the activity as you usually do it.

Section 1: Multiple Choice Questions

Understanding and Communicating

In the last 30 days, how much difficulty did you have…	**None**	**Mild**	**Moderate**	**Severe**	**Extreme/ Cannot Do**
Concentrating on doing something for ten minutes?					
Remembering to do important things?					
Analyzing and finding solutions to problems in day to day life?					

In the last 30 days, how much difficulty did you have…	None	Mild	Moderate	Severe	Extreme/ Cannot Do
Learning a new task (for example, finding your way to a new place)?					
Generally understanding what people say?					
Starting and maintaining a conversation?					
If any of the above are rated greater than none, how much did these difficulties interfere with your life?					

Getting Around

In the last 30 days, how much difficulty did you have…	None	Mild	Moderate	Severe	Extreme/ Cannot Do
Standing for long periods such as 30 minutes?					
Standing up from sitting down?					
Moving around inside your facility?					
Getting out of your facility?					
Walking a long distance such as a mile?					
Getting out of bed?					
If any of the above are rated greater than none, how much did these difficulties interfere with your life?					

Section 2: Short Answer Questions

Below are selected questions for use in patient and medical staff structured interviews. If a question is answered “yes”, move to the lower level of that question, and then each subsequent level if included.

In the last 30 days, did you:

1. Use assistive technology to help you perform a physical function? Examples of assistive technologies might be a prosthetic device, wheelchair, walker, personal assistant, brace, or crutches.
    a. What technology?
    b. For what function?
    c. Did you experience any difficulty using the technology?

        i. What was the nature of the difficulty?
    d. Were there any improvements that you would like to see in the assistive technology to help you perform the functions you need to perform?
2. Use technology such as a computer, internet, smart phone or similar device, or MP3 player?
    a. What technology?
    b. For what function?
    c. Did you experience any difficulty using the technology?
        i. What was the nature of the difficulty?
    d. Were there any improvements that you would like to see in the assistive technology to help you perform the functions you need to perform?
3. Have any vision problems?
    a. What was the nature of the problem?
4. Have any hearing problems?
    a. What was the nature of the problem?
5. Have any problems communicating?
    a. What was the nature of the problem?
6. Have any problems using your hands?
    a. What was the nature of the problem?

Section 3: Injuries and Voting

1. How long has it been since you were injured? [Prompt date of injury]
2. How long did it take for you to get back to the US for treatment? [Prompt: date arriving in US]
3. With that in mind, can you describe the general nature of your injury or injuries?
4. What medical equipment do you need on a regular basis (for example, IVs, monitors, or oxygen)?
5. Are there any restrictions on how long you can be away from your room or home? If yes, what are the restrictions?
6. Since you became ill/injured, have you attempted to register to vote, request an absentee ballot, or vote?
    a. Were you successful?
7. What are the greatest challenges you face in voting?
8. Did you face similar challenges before you were injured?
    a. What obstacles did you run into?

Interviewer Notes: